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An International Journal of Astronomy.

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OBSERVATIONS OF THE SPECTRUM OF COMET 1880 *d* (Hartwig).

(Communicated by the Earl of Crawford and Balcarres.)

The spectrum as observed with a compound Grubb prism consisted of three bands, of which the one nearest the red showed two feeble maxima, as if the band were really double. This band faded gradually off at both ends, while the other two were sharply bounded on the redward side.

The following measures were made with a single bright wire (spider's thread), the illumination of which can be regulated to the greatest nicety :—

——	Oct. 4.	No. of Observations.	Oct. 7.	No. of Observations.	Oct. 10.	No. of Observations.
	mmm.		mmm.		mmm.	
Extreme redward end, ...	565·9	1	564·5	1	567·0	1
1st band—1st condensation, . . .	557·0	2	552·4	1	556·6	2
„ „ very slightly fainter than the band on either side, ...	552·6	1	—	–	—	–
„ „ 2nd condensation, . . .	545·1	2	545·5	1	546·9	2
„ „ end, ...	532·5	1	535·2	1	529·6	1
2nd band—limit towards the red, . .	516·5	4	516·7	2	518·0	1
„ „ brightest part, . . .	513·6	3	513·0	3	516·3	4
„ „ end, ...	493·0	1	493·1	1	491·0	1
3rd band—limit towards the red, . .	473·0	2	472·6	1	472·7	1
„ „ maximum, ...	469·2	1	468·3	3	471·4	3
„ „ extreme limit of spectrum, . .	458·7	1	460·3	1	458·1	2
Width of slit at D, ...	3·3		4·2		2·8	
Observer, ...	R. C.		J. G. L.		R. C.	

Beginning with the double band the relative brightness was estimated as follows :—

Oct. 4, . . .	3	20	4
Oct. 7, . . .	4	20	4
Oct. 10, . . .	3½ and 3	20	4

On October 7, at a distance of a full minute of arc from the head of the comet, the tail still showed the three bands, but they seemed to be more sharply bounded towards the red than in the actual coma.

On October 10, with the slit opened to its full extent, an exceedingly faint connexion with the three bands could be made out, but no trace was detected of other lines towards the red or violet, nor of a continuous spectrum, properly so called.

Ralph Copeland.
J. G. Lohse.

A NEW PLANETARY NEBULA. By RALPH COPELAND, Ph. D.

(Communicated by the Earl of CRAWFORD and BALCARRES.)

In the number of the "American Journal of Science" for October, 1880, Professor Edward C. Pickering gives a most interesting account of a method of sweeping the heavens for small planetary nebulæ.

By placing a direct-vision prism between the eye-piece and the object glass the images of the stars are drawn out into long spectra, while those of the planetary nebulæ remain nearly undistorted. Professor Pickering gives the places and general descriptions of four remarkable small objects discovered in this way.

At the suggestion of Lord Lindsay, on November 7, a prism was combined on this plan, with a Huyghenian eye-piece in the 15·06 in. Dunecht refractor. In a short time it was found that whenever a bright star was near the field of view, it gave rise to a monochromatic image in the prolongation of the red end of the spectrum. This seems to be due to reflection from one of the surfaces of the prism. If, however, the prism is so placed that the spectra enter the field by the daily motion, *red end first*, these spurious images move in the opposite direction to the other images. For this reason, and because they are only formed by very bright stars, they do not interfere seriously with the progress of a search.

Owing to general bad weather, and the use of the telescope during the short clear intervals, for the observation of comet 1880 *e* (Swift) no good sweeps were made until November 18, when a round disc, altogether different from the spurious images just mentioned entered the field. As the weather was very threatening the prism was exchanged for the micrometer, and the position of the stranger measured from a couple of neighbouring stars. This was done under the impression that the object might after all be a comet. The resulting approximate place for 1880·0, is:—

R.A. $21^{\mathrm{h}}\ 2{\cdot}2^{\mathrm{m}}$ Decl. $+\ 47^{\circ}\ 22'$

The measures not showing a perceptible change of place, I felt at liberty to proceed to a more thorough spectroscopic examination with a Grubb one-prism spectroscope, but it was not until $17^{\mathrm{h}}\ 30^{\mathrm{m}}$, G.M.T., that an opening in the clouds permitted an observation. Although by this time nearly *sub polo* the spectrum was at once seen to consist of two very sharp bright lines with a suspicion of a third. This put the nebular character of the object beyond all doubt.

On November 21, Mr. Lohse, Mr. Carpenter and I all saw that the nebula had two imperfectly defined nuclei, giving it very much the appearance of the older drawings of the "Dumb bell" nebula. On November 29 I found the relative position of the nuclei by two measures.

Pos.	$72^{\circ}{\cdot}7$	Dist.	$7''{\cdot}9$
	71·0		8·1

The diameter of the nebula being some 12″.

The place of the nebula was also measured from several known stars, but the results still await a final examination.

On December 3 the two brightest lines of the spectrum were easily measured, but nothing could be made of the third one until December 6, when not only were all three satisfactorily measured, but also faint traces of an additional line seen further up in the violet, the position of which could only be estimated.

Although far fainter, this body has so much in common with its not distant neighbour, the Stephan-Webb nebula,

	H.	M.		°	′
R.A.	21	2·5	Decl. +	41	45

that Mr. Lohse and I hoped we might find this additional line in the spectrum of that body. By a strange chance, as will be seen, the right ascensions differ only a few seconds, so by turning the telescope somewhat over 5° in declination, the Stephan-Webb nebula was brought on the slit of the spectroscope almost without otherwise disturbing the telescope. All four lines were at once seen in the same relative positions and easily measured. The mean results for both days and objects are here given together:—

——	1	No. of Observations	2	No. of Observations	3	No. of Observations	4	No. of Observations	Observer.
	mmm.		mmm.						
Dec. 3. Nova, . .	501·1	5	496·4	5	—	–	—	–	R. C.
„ 6. „ . .	501·2	7	496·1	4	486·1	5	—	–	R. C.
„ „ „ . .	500·6	5	496·0	5	487·0	3	—	–	J. G. L.
„ „ Stephan-Webb, .	501·9	4	496·9	3	487·2	3	469·4	4	J. G. L. & R. C.
Relative brightness (Nova),	80		16		4		1		

The lines 3 and 4 were about five times as bright in the Stephan-Webb nebula as in the Nova.

The fourth line is not improbably of the same wave length as the one seen by Dr. Huggins in Gen. Cat. 4964, who thus describes its position :—"This line is about as much more refrangible than the line agreeing in position with F, as this line is more refrangible than the brightest of the lines which coincides with a line of nitrogen."

The fourth line agrees well with an oxygen line, and it may be mentioned that the spectrum of C H shows also a band in the same region. On the other hand it is entirely distinct from the fourth line of the Orion nebula, which is readily seen with the Dunecht instruments, and which is most probably coincident with H_γ wave length 434·0.

Dunecht Observatory,
Decr. 14, 1880.

OBSERVATIONS OF COMETS MADE AT DUNECHT OBSERVATORY.

(Communicated by the Earl of CRAWFORD and BALCARRES.)

COMET SCHÄBERLE.

Comparison Star.	Date. 1880.	Dunecht Mean Time.	Comet −*		α Comet.	δ Comet.	Observer.
			Δα.	Δδ.			
		H. M. S.	M. S.	′ ″	H. M. S.	° ′ ″	
a	Sept. 13,	15 12 32·8		+0 43·3		+19 38 27·2	R. C.
a	„ „	15 19 58·2	−2 6·44		6 53 3·21		R. C.
b	Oct. 10,	14 0 11·6	+0 13·99	+6 23·3	6 21 42·68	+ 7 18 33·4	J. G. L.
COMET HARTWIG.							
c	Oct. 4,	7 41 32·1		−7 32·3		+26 33 2·9	J. G. L.
c	„ „	7 44 7·7	+1 58·88		15 39 42·44	+21 5 4·9	J. G. L.
d	„ 10,	8 37 31·6	+0 7·16	−5 30·0	16 47 39·93		J. G. L.
COMET FAYE.							
e	Sept. 13,	12 4 48·7	−0 11·25	+3 0·2	22 59 42·63	+ 8 18 27·4	R. C.

PLACES OF COMPARISON STARS FOR 1880·0.

	α H. M. S.	Red. to date.	δ ° ′ ″	Red. to date.	
a	6 55 6·44	+3·21	+19 37 46·2	− 2·3	B. W. VI. 1623.
b	6 21 24·80	+3·89	+ 7 12 6·1	+ 4·0	Lalande 12363.
c					γ Cor. bor. Auwers' Fund. Cat.
d	16 47 30·74	+2·03	+21 10 29·8	+ 5·1	B. W. XVI., 1448.
e	22 59 49·45	+4·43	+ 8 14 58·8	+28·4	½(Lalande 45182·3+Dreyer. α, 22^h 59^m 49^s·44, δ, +8° 14′ 56″·8. Dunsink Transit Circle Obs.)

Sept. 13, Comet	Faye.	Traces of tail with power 229, and lowest power in direction pos. 240°·8.
„ „ „	Schäberle.	Comet very small, 1′ diameter; very faint; images bad; sky hazy; power 229.
Oct. 4, „	Hartwig.	Position of tail, pos. 60°·8. Tail faint but long. App. diameter of coma 2′ 28″.
„ 10, „	„	Comet scarcely bears bright field; power 229. Position of tail, n. f. 63°·6; the tail is very broad and comparatively faint, and its position is not easily determinable; the comet has not a real nucleus, but the brightness in the centre vastly exceeds that of the coma.
„ „ „	Schäberle.	Comet pretty conspicuous when clear of stars, a tail even being then shown, but the comet itself is hardly recognisable when near a *9·5 mag.

The observations are not corrected for parallax or aberration. Observers—RALPH COPELAND and J. G. LOHSE.

UEBER DIE AUFLÖSUNG DER LAMBERT'SCHEN GLEICHUNG FÜR PARABOLISCHE BEWEGUNG. Von Professor W. Klinkerfues.

Olbers soll die erste praktische Anwendung seiner "leichtesten und bequemsten Methode, die Bahn eines Cometen zu berechnen" in Nachtstunden gemacht haben, welche er als Arzt an einem Krankenbette zubringen musste. Dreiundachtzig seitdem verflossene Jahre haben die Methode immer mehr und mehr in der Gunst der Astronomen befestigt, besonders, nachdem Gauss seine Meisterhand etwas umformend an dieselbe gelegt hatte. Bekanntlich erfordert die Methode die Auflösung der Lambert'schen Gleichung für parabolische Bahnen, welche nur durch Versuche erlangt werden kann. Zu diesem oft behandelten Thema möchte ich im Folgenden einen Beitrag liefern.

Der Lambert'schen Gleichung, also der phoronomischen Relation für die zwischen den Zeiten t und t'' durchlaufene Sehne κ gibt Encke (Berl. Jahrb. für 1833) die sehr viel geschmeidigere Form—

(1.)
$$\kappa = \frac{2k(t''-t)}{(r+r'')^{\frac{1}{2}}}\,\mu.$$

Log μ ist abhängig von der Grösse η oder—

$$\frac{2k(t''-t)}{(r+r'')^{\frac{3}{2}}}$$

und ist einer kleinen Hülfstafel mit dem Argumente η zu entnehmen, k ist die bekannte Gaussche Gravitations-Constante. Der Kürze halber sei noch $k(t''-t) = \vartheta'$, $r+r''=\mathrm{S}$, demnach—

(2.)
$$\kappa = \frac{2\vartheta'}{\mathrm{S}^{\frac{1}{2}}}\cdot\mu.$$

Unmittelbares Object der Versuche ist die bekannte, von Gauss mit u bezeichnete Grösse, durch welche sich sowohl κ, als auch r und r'', zuletzt auch die Abstände von der Erde, einfach ausdrücken lassen. Die Versuche sind erledigt, wenn der Sehnenwerth der rein geometrischen Relation—

(3.)
$$\kappa^2 = u^2 + \mathrm{A}^2,$$

mit dem aus (1) oder (2) folgenden phoronomischen Werthe übereinstimmt. Der Anfangspunkt der Versuchs—oder Verbesserungsreiche wird gewonnen, indem man, wenigstens für gewöhnlich, in Gleichung (2) S=2·0 setzt. Es folgt dann aus (3) der entsprechende Werth von u und aus den Gleichungen—

(4.)
$$r^2 = \left(\frac{u+c}{f}\right)^2 + \mathrm{B}^2.$$

(5.)
$$r''^2 = \left(\frac{u+c''}{f''}\right)^2 + \mathrm{B}''^2,$$

der Gaussischen Bezeichnung der Radien vectoren, deren Summe S von Neuem in (1) und (2) substituirt wird, um aus (3) ein verbessertes u, aus (4) und (5) wiederum ein verbessertes S abzuleiten, bis schliesslich sich nichts mehr ändert.

So sehr nun auch dieses von Encke angegebene systematische Verfahren den Vorzug verdient vor eigentlichem Tâtonnement, sind doch in der Regel mindestens vier Substitutionen erforderlich, die übliche Schärfe zu erlangen. Man kann aber diese Zahl von Substitutionen auf die Hälfte herabsetzen, ohne dass die einzelne erheblich beschwerlicher wird. Zu dem Zwecke setzt man—

$$u = u_0 + x,$$

wobei x die an die Annäherung u_0 anzubringende Verbesserung vorstellt, und macht in dieser Form die Proben. Die zur Rechnung erforderlichen Ausdrücke erhält man leicht durch den binomischen Lehrsatz. Bei der Entwicklung r und r'' braucht man die Glieder mit x^2 schon nicht mehr zu berücksichtigen, weil dieselben nachher mit ϑ' multiplicirt werden müssten und zu Gliedern der dritten Ordnung herabsinken würden. Nur bei dem geometrischen Werthe der Sehne—

$$\{(u_0+x)^2 + A^2\}^{\frac{1}{2}},$$

muss auch x^2 mitgenommen werden, wenn die Versuche wirksam vermindert werden sollen.

Es sei nun im Anschluss an eine bekannte Bezeichung—

$$r^2 = B^2 + \left(\frac{u_0+c}{f}\right)^2; \quad r = \left\{B^2 + \left(\frac{u_0+c}{f}\right)^2 + \frac{2(u_0+c)x}{f}\right\}^{\frac{1}{2}} = r_0 + \frac{u_0+c}{fr_0}x.$$

$$r_0''^2 = B''^2 + \left(\frac{u_0+c''}{f''}\right)^2; \quad r_0'' = \left\{B''^2 + \left(\frac{u_0+c''}{f''}\right)^2 + \frac{2(u_0+c'')x}{f''}\right\}^{\frac{1}{2}} = r_0'' + \frac{u_0+c''}{f''r_0''}x.$$

$$S_0 = r_0 + r_0''; \quad s_0 = \frac{u_0+c}{fr_0} + \frac{u_0+c''}{f''r_0''}.$$

$$\kappa_0^2 = A^2 + u_0^2,$$

dann drückt sich die Bedingung, dass das phoronomische κ gleich dem geometrischen werden soll, durch folgende quadratische Gleichung aus—

$$\left(\frac{1}{2\kappa_0} - \frac{u_0^2}{2\kappa_0^3}\right)x^2 + \left(\frac{u_0}{\kappa_0} + \frac{\vartheta'\mu_0 s_0}{S_0^{\frac{3}{2}}}\right)x = \frac{2\vartheta'\mu_0}{S_0^{\frac{1}{2}}} - \kappa_0. \tag{6.}$$

μ_0 ist hier derjenige Werth des Factors μ in Gleichung (2), welcher aus u_0 oder S_0 folgt.

Bei dem ersten Versuche setzt man mit Vortheil—

$$\kappa_0 = \frac{\vartheta'}{(R' \sin \tfrac{1}{2} \psi')^{\frac{1}{2}}}$$

also—

$$u_0 = \sqrt{\frac{\vartheta'^2}{R' \sin \tfrac{1}{2} \psi'} - A^2}$$

worin ψ' den Abstand des geocentrischen Orts der zweiten Beobachtung vom Sonnenort bedeutet, zu finden aus der einfachen Formel—

$$\cos \psi' = \cos \beta' \cos(\lambda' - \odot').$$

Es kann dies aber hier nur flüchtig bemerkt werden.

RECHNUNGS-BEISPIEL. (Comet 1813, II.)

$\log B = 9{\cdot}98706.$ $\log B'' = 9{\cdot}86038.$
$\log f = 9{\cdot}75645.$ $\log f'' = 0{\cdot}05028.$
$c = 0{\cdot}31365.$ $c'' = 0{\cdot}95443.$
$\log \vartheta' = 9{\cdot}38304.$ $\psi' = 244° \; 12'{\cdot}1.$
$\log R' = 0{\cdot}00175.$

Hiernach ist die erste Probe zu machen mit—

$$\log \kappa_0 = 9{\cdot}41820, \text{ oder } u_0 = 0{\cdot}20098;$$

ferner ergibt sich :—

$$\log r_0 = 0{\cdot}12116. \qquad \log r_0'' = 0{\cdot}09997.$$
$$\log S_0 = 0{\cdot}41172. \qquad \log s_0 = 0{\cdot}17599.$$
$$\eta_0 = 0{\cdot}11654. \qquad \log \mu_0 = 0{\cdot}00025.$$
$$\frac{2\vartheta'\mu_0}{S_0^{\frac{1}{2}}} = 0{\cdot}30092. \qquad \kappa_0 = 0{\cdot}26194.$$

Von allen diesen Werthen wären bei dem gewöhnlichen Verfahren nur der von s_0 und, wenn man will, ψ', nicht zu berechnen gewesen ; aber die leichte Mühe macht sich belohnt. Gleichung (6) wird—

$$0{\cdot}78520x^2 + 0{\cdot}85471x = 0{\cdot}03898,$$

woraus folgt—

$$x = 0{\cdot}04372.$$
$$u_0 + x = 0{\cdot}24470.$$

Dieser letztere Werth wäre nun im Weiteren als u_0 zu behandeln ; man findet—

$$\log r_0 = 0{\cdot}13928. \qquad \log r_0'' = 0{\cdot}11090.$$
$$\log S_0 = 0{\cdot}42633. \qquad \log s_0 = 0{\cdot}18674.$$
$$\eta_0 = 0{\cdot}11081. \qquad \log \mu_0 = 0{\cdot}00022.$$
$$\frac{2\vartheta'\mu_0}{S_0^{\frac{1}{2}}} = 0{\cdot}29589. \qquad \kappa_0 = 0{\cdot}29681.$$

Die Berechnung des Coefficienten von x^2 ist bei der zweiten Annäherung überflüssig ; das entsprechende Glied spielt keine Rolle mehr. Die Bedingungsgleichung (6) wird daher—

$$0{\cdot}90965x = -0{\cdot}00092.$$

daher—

$$x = -0{\cdot}00101.$$

mithin das neue $u_0 = 0{\cdot}24369$. Zu grösserer Sicherheit prüfte ich auch noch diesen Werth und fand die phoronomische Sehne=0·29599, die geometrische=0·29596. Aber der Unterschied 0·00003 ist kleiner als der mögliche Einfluss der Tafelfehler, und eine weitere Verbesserung hätte nur illusorischen Werth.

In der Praxis gestaltet sich die Sache nun dadurch noch etwas einfacher, dass kaum jemals sich ein Fall ereignen dürfte, wo nicht schon die zweite Verbesserung die scharfe Lösung herbeiführt. So wird in obigem Beispiele auf eine aller Willkür entzogene Weise die Hypothese gebildet—

$$u_0 = 0{\cdot}20098.$$

Die erste Verbesserung wird—

$$x = 0{\cdot}04372,$$

die zweite gleich—

$$-0{\cdot}00101.$$

Bezeichne ich allgemein die zweite mit x', so ist so gut wie immer—

$$u_0 + x + x' - \frac{x'}{x} . x'$$

die scharfe Lösung für u, im gegenwärtigen Falle also—

$$0{\cdot}20098 + 0{\cdot}04372 - 0{\cdot}00101 - \frac{1}{44}(-0{\cdot}00101).$$

also—

$$u = 0{\cdot}24371.$$

Göttingen, den 12ten December, 1880.

HÜLFSTAFELN ZUR ERLEICHTERUNG DER BERECHNUNG VON STERNBEDECKUNGEN DURCH DEN MOND. Von Dr. C. Börgen.

Die Wichtigkeit der Sternbedeckungen für die Theorie der Mondbewegung sowohl, wie für die Bestimmung der Längendifferenz zweier Orte wird es gewiss annehmbar erscheinen lassen die Berechnung derselben in einer seiner lästigsten Phasen etwas zu vereinfachen und durch Hülfstafeln, welche, soviel dem Verfasser bekannt ist, bisher noch nicht veröffentlicht sind zu erleichtern. Die hier gegebenen Hülfstafeln wurden von dem Verfasser bereits vor sieben Jahren berechnet und seitdem mehrfach mit Erfolg angewendet.

Die Berechnung der Längendifferenz eines Ortes von dem Grundmeridian (als welchen wir Greenwich annehmen) nach der Besselschen Methode geshieht bekanntlich auf folgende Weise.

Wendet man die folgende Bezeichnung an.

t = beob. mittl. Zeit der beobachteten Phase (z. B. des Eintrittes).
θ = — Sternzeit.
$T=t+d=$die genäherte Greenwicher Zeit.
$a, \delta=$Æ und Decl. des Mondes.
$a', \delta'=$Æ und Decl. des Sternes.
$\pi=$Horiz. Aequatoreal Parallaxe des Mondes.
$k=0{\cdot}2725$.
$\rho, \phi'=$Radius vector und geoc. Breite des Beobachtungsorts.
$\left.\begin{matrix}\xi, \eta \\ x_0, y_0\end{matrix}\right\}$ =coordinaten zur Zeit T $\left\{\begin{matrix}\text{des Erdorts.} \\ \text{des Mondes.}\end{matrix}\right.$
$x', y'=$Erste Differentialquotienten der Mond coordinaten,

so hat man zu berechnen—

(1.) $\xi=\rho \cos \phi' \sin(\theta-a')$.
$\eta=\rho \sin \phi' \cos \delta'-\rho \cos \varphi' \sin \delta' \cos(\theta-a')$.
(2.) Für drei um T herumliegende volle Stunden Greenwicher Zeit.

$$x=\frac{\cos \delta \sin(a-a')}{\sin \pi}$$

$$y=\frac{\sin \delta \cos \delta'- \cos \delta \sin \delta' \cos(a-a')}{\sin \pi}$$

(3.) Man interpolire für die Zeit T die Werthe x_0, y_0, x' und y' und berechne m, M und n, N aus:
(4) $m \sin M=x_0-\xi$ und $n \sin N=x'$.
$m \cos M=y_0-\eta$ $\quad n \cos N=y'$.
$k \sin \psi=m \sin(M-N)$.
$c \log k=0{\cdot}564634$,

dann ist die wahre Längendifferenz vom Grundmeridian—

$$(5.)\quad d=t-T+\frac{m}{n}\cdot\frac{\sin(M-N+\psi)}{\sin \psi}3600^s+\frac{h \cos \delta \sin(N-\psi)}{\cos \psi}\Delta(a-a')+\frac{h \cos(N-\psi)}{\cos \psi}\Delta(\delta-\delta'),$$

worin —

$$h = \frac{3600}{206265\, n \sin \pi}.$$

Unter diesen Formeln ist diejenige für y, welche dreimal berechnet werden muss in einer für die numerische Rechnung sehr unbequemen Form gegeben. Sie lässt sich aber leicht auf eine Form bringen, welche der von x analog ist und sich mit Hülfe der im Nachfolgenden gegebenen Tafel ebenso bequem berechnen lässt wie die für x. Zu dieser Form gelangt man auf folgende Weise—

$$y \sin \pi = \cos \delta' \{\sin \delta - \cos \delta \operatorname{tang} \delta' \cos(\alpha - \alpha')\},$$

setzen wir hierin—

$$\operatorname{tang} \delta' \cos(\alpha - \alpha') = \operatorname{tang}(\delta' - \gamma),$$

so wird—

$$y \sin \pi = \cos \delta' \left\{ \sin \delta - \cos \delta \frac{\sin(\delta' - \gamma)}{\cos(\delta' - \gamma)} \right\} = \sin(\delta - \delta' + \gamma) \frac{\cos \delta'}{\cos(\delta' - \gamma)} \text{ und } y = \frac{\sin(\delta - \delta' + \gamma)}{\sin \pi} \cdot \frac{\cos \delta'}{\cos(\delta' - \gamma)}$$

Zur Bestimmung von γ haben wir—

$$\frac{\sin(\delta' - \gamma)}{\cos(\delta' - \gamma)} = \frac{\sin \delta'}{\cos \delta'} \left\{ 1 - 2 \sin^2 \tfrac{1}{2}(\alpha - \alpha') \right\},$$

woraus leicht—

$$\begin{aligned} \sin \gamma &= 2 \sin \delta' \cos(\delta' - \gamma) \sin^2 \tfrac{1}{2}(\alpha - \alpha') \\ &= \sin 2\delta' \sin^2 \tfrac{1}{2}(\alpha - \alpha'), \end{aligned}$$

da wir unbedenklich $\cos(\delta' - \gamma) = \cos \delta'$ setzen dürfen.

Die nachfolgende Tafel giebt nun die Werthe von γ in Bogensekunden und von $\log \frac{\cos \delta'}{\cos(\delta' - \gamma)}$ in Einheiten der 6ten Decimalstelle. Die letzteren sind durchweg so klein, dass sie in sehr vielen Fällen vernachlässigt werden können, und ist dann die Berechnung des y noch einfacher als die von x. γ has gleiches Vorzeichen mit der Declination des Sternes und ist mit diesem Zeichen an die Differenz $\delta - \delta'$ auzubringen.

Der Tafel für γ haben wir noch eine kleine Hülfstafel zur Berechnung von $\log \rho \sin \phi'$ und $\log \rho \cos \phi'$ vorangesetzt. Dieselbe ist nach der bekannten Formel berechnet, wonach wenn e die Excentricität des Erdmeridians und ϕ die Polhöhe des Orts bedeuten—

$$\sin \psi = e \sin \phi,$$

und—

$$\begin{aligned} \log \rho \sin \phi' &= \log \sin \phi - \log \cos \psi \\ \log \rho \cos \phi' &= \log \cos \phi + \log \cos \psi. \end{aligned}$$

Zum Ueberfluss möge noch ein Beispiel die Rechnungsmethode erläutern, wobei wir uns jedoch auf den Theil der Rechnung beschränken, der sich auf die Berechnung von y bezieht.

Am 20 Nov., 1877, wurde in Wilhelmshaven die Bedeckung von 17 Tauri um $8^h\ 4^m\ 56^s{\cdot}9$ m. Z. beobachtet. Der Ort des Sterns ist $\alpha' = 3^h\ 37^m\ 39^s{\cdot}48$, $\delta' = +23^\circ\ 43'\ 52''{\cdot}6$ und die Polhöhe des Orts $\phi = 53^\circ\ 31'\ 52''{\cdot}0$ sowie die Länge $= 32^m\ 35^s{\cdot}2$ Ost v. Gr. Aus dem Naut Alm. findet sich—

	α	δ	$\alpha - \alpha'$	$\delta - \delta'$	π
7^h	$3^h\ 33^m\ 22^s{\cdot}16$	$+24^\circ\ 20'\ 23''{\cdot}8$	$-1^\circ\ 4'\ 19''{\cdot}80$	$+36'\ 31''{\cdot}2$	$57'\ 8''{\cdot}5$
8	35 43 ·87	28 14 ·7	−0 28 54 ·15	+44 22 ·1	9 ·9
9	38 5 ·98	35 57 ·6	+0 6 37 ·50	+52 5 0	11 ·4

Mit δ' und $\alpha-\alpha'$ findet man aus der Tafel—

	γ	$\log \frac{\cos \delta'}{\cos(\delta'-\gamma)}$	$\delta-\delta'+\gamma$
7^h	$+13''\cdot10$	-11	$+36'\ 44''\cdot30$
8	$+\ 1\ \cdot54$	$-\ 1$	$+44\ \ 23\ \cdot64$
9	$+\ 0\ \cdot14$	0	$+52\ \ 5\ \cdot14$

und—

	7^h	8^h	9^h
$\sin(\delta-\delta'+\gamma)=$	8·028837	8·111038	8·180428
$\operatorname{cosec}\pi =$	1·779341	1·779164	1·778974
$\log\frac{\cos\delta'}{\cos(\delta'-\gamma)} =$	-11	-1	0
$\log y =$	9·808167	9·890201	9·959402
$y =$	0·642968	0·776610	0·910756

Wilhelmshaven, December 8, 1880.

ϕ.	A.	Diff.	B.	ϕ.	A.	Diff.	B.	ϕ.	A.	Diff.	B.
0°	2908	1	0	30°	2545	22	363	60°	1818	22	1090
1	2907	1	1	31	2523	22	385	61	1796	21	1112
2	2906	2	2	32	2501	23	407	62	1775	21	1133
3	2904	3	4	33	2478	23	430	63	1754	20	1154
4	2901	4	7	34	2455	24	453	64	1734	20	1174
5	2897	5	11	35	2431	24	477	65	1714	19	1194
6	2892	6	16	36	2407	24	501	66	1695	19	1213
7	2886	6	22	37	2383	25	525	67	1676	18	1232
8	2880	8	28	38	2358	25	550	68	1658	17	1250
9	2872	8	36	39	2333	25	575	69	1641	16	1267
10	2864	9	44	40	2308	25	600	70	1625	16	1283
11	2855	10	53	41	2283	25	625	71	1609	15	1299
12	2845	11	63	42	2258	25	650	72	1594	15	1314
13	2834	11	74	43	2233	25	675	73	1579	14	1329
14	2823	12	85	44	2208	25	700	74	1565	13	1343
15	2811	13	97	45	2183	26	725	75	1552	13	1356
16	2798	14	110	46	2157	26	751	76	1539	11	1369
17	2784	15	124	47	2131	25	777	77	1528	11	1380
18	2769	15	139	48	2106	26	802	78	1517	10	1391
19	2754	16	154	49	2080	25	828	79	1507	9	1401
20	2738	16	170	50	2055	25	853	80	1498	8	1410
21	2722	17	186	51	2030	24	878	81	1490	8	1418
22	2705	18	203	52	2006	24	902	82	1482	6	1426
23	2687	19	221	53	1982	24	926	83	1476	6	1432
24	2668	19	240	54	1958	24	950	84	1470	5	1438
25	2649	20	259	55	1934	24	974	85	1465	4	1443
26	2629	20	279	56	1910	24	998	86	1461	3	1447
27	2609	20	299	57	1886	23	1022	87	1458	2	1450
28	2589	22	319	58	1863	22	1045	88	1456	1	1452
29	2567	22	341	59	1840	22	1068	89	1455	1	1453
30	2545	22	363	60	1818	22	1090	90	1454		1454

$\log \rho \sin \phi' = \log \sin \phi - \text{A}.$
$\log \rho \cos \phi' = \log \cos \phi + \text{B}.$

δ=0° bis ±6°. δ'.

$a-a'$.	0°.		±1°.		±2°.		±3°.		±4°.		±5°.		±6°.	
	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.
		—		—		—		—		—		—		—
0	0″·00	0	0·00	0	0″·00	0	0·00	0	0″·00	0	0″·00	0	0″·00	0
1	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0
2	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0
3	·00	0	·00	0	·00	0	·00	0	·01	0	·01	0	·01	0
4	·00	0	·00	0	·00	0	·01	0	·01	0	·01	0	·01	0
5	·00	0	·00	0	·01	0	·01	0	·02	0	·02	0	·02	0
6	0·00	0	0·01	0	0·01	0	0·02	0	0·02	0	0·03	0	0·03	0
7	·00	0	·01	0	·01	0	·02	0	·03	0	·04	0	·04	0
8	·00	0	·01	0	·02	0	·03	0	·04	0	·05	0	·06	0
9	·00	0	·01	0	·02	0	·03	0	·05	0	·06	0	·07	0
10	·00	0	·01	0	·03	0	·04	0	·06	0	·07	0	·09	0
11	0·00	0	0·02	0	0·04	0	0·05	0	0·07	0	0·09	0	0·11	0
12	·00	0	·02	0	·04	0	·06	0	·09	0	·11	0	·13	0
13	·00	0	·02	0	·05	0	·07	0	·10	0	·12	0	·15	0
14	·00	0	·03	0	·06	0	·09	0	·12	0	·14	0	·18	0
15	·00	0	·03	0	·07	0	·10	0	·14	0	·17	0	·20	0
16	0·00	0	0·04	0	0·08	0	0·12	0	0·16	0	0·20	0	0·23	0
17	·00	0	·04	0	·09	0	·14	0	·18	0	·22	0	·26	0
18	·00	0	·05	0	·10	0	·15	0	·20	0	·24	0	·29	0
19	·00	0	·05	0	·11	0	·16	0	·22	0	·27	0	·33	0
20	·00	0	·06	0	·12	0	·18	0	·24	0	·30	0	·36	0
21	0·00	0	0·06	0	0·13	0	0·20	0	0·27	0	0·34	0	0·40	0
22	·00	0	·07	0	·15	0	·22	0	·29	0	·36	0	·44	0
23	·00	0	·08	0	·16	0	·24	0	·32	0	·40	0	·48	0
24	·00	0	·09	0	·18	0	·26	0	·35	0	·43	0	·52	0
25	·00	0	·10	0	·19	0	·28	0	·38	0	·47	0	·57	0
26	0·00	0	0·10	0	0·21	0	0·31	0	0·41	0	0·51	0	0·61	0
27	·00	0	·11	0	·22	0	·33	0	·44	0	·55	0	·66	0
28	·00	0	·12	0	·24	0	·36	0	·48	0	·60	0	·71	0
29	·00	0	·13	0	·26	0	·38	0	·51	0	·64	0	·76	0
30	·00	0	·13	0	·27	0	·41	0	·55	0	·68	0	·82	0
31	0·00	0	0·15	0	0·29	0	0·43	0	0·58	0	0·72	0	0·87	0
32	·00	0	·16	0	·31	0	·47	0	·62	0	·77	0	·93	0
33	·00	0	·17	0	·33	0	·49	0	·66	0	·83	0	·99	0
34	·00	0	·18	0	·35	0	·53	0	·70	0	·88	0	1·05	0
35	·00	0	·19	0	·37	0	·55	0	·74	0	·93	0	1·11	0
36	0·00	0	0·20	0	0·39	0	0·59	0	0·79	0	0·98	0	1·18	0
37	·00	0	·21	0	·42	0	·63	0	·83	0	1·03	0	1·24	0
38	·00	0	·22	0	·44	0	·66	0	·88	0	1·09	0	1·31	0
39	·00	0	·23	0	·46	0	·69	0	·92	0	1·15	0	·38	0
40	·00	0	·24	0	·49	0	·73	0	·97	6	1·21	0	1·45	0
41	0·00	0	0·26	0	0·51	0	0·76	0	1	0	1·27	0	1·53	0
42	·00	0	·27	0	·54	0	·80	0	1·07	0	1·33	0	1·60	0
43	·00	0	·29	0	·57	0	·84	0	1·12	0	1·40	0	1·68	0
44	·00	0	·29	0	·59	0	·88	0	1·18	0	1·47	0	1·76	0
45	·00	0	·31	0	·62	0	·92	0	1·23	0	1·54	0	1·84	0
46	0·00	0	0·32	0	0·64	0	0·96	0	1·28	0	1·60	0	1·92	0
47	·00	0	·34	0	·67	0	1·00	0	1·34	0	1·67	0	2·00	0
48	·00	0	35	0	·70	0	1·05	0	1·40	0	1·74	0	2·09	0
49	·00	0	·37	0	·73	0	1·10	0	1·46	0	1·82	0	2·18	0
50	·00	0	·38	0	·76	0	1·14	0	1·52	0	1·90	0	2·27	0
51	0·00	0	0·40	0	0·79	0	1·18	0	1·58	0	1·97	0	2·36	0
52	·00	0	·41	0	·82	0	1·23	0	1·64	0	2·04	0	2·45	0
53	·00	0	·43	0	·86	0	1·28	0	1·71	0	2·13	0	2·55	0
54	·00	0	44	0	·89	0	1·33	0	1·77	0	2·21	0	2·65	0
55	·00	0	·46	0	·92	0	1·38	0	1·84	0	2·29	0	2·74	1
56	0·00	0	0·48	0	0·95	0	1·42	0	1·90	0	2·38	0	2·85	1
57	·00	0	·49	0	·99	0	1·48	0	1·97	0	2·46	0	2·95	1
58	·00	0	·51	0	1·02	0	1·53	0	2·04	0	2·54	0	3·05	1
59	·00	0	·53	0	1·06	0	1·58	0	2·11	0	2·63	0	3·16	1
60	·00	0	·55	0	1·10	0	1·64	0	2·19	0	2·73	0	3·27	1

$\delta = \pm 6^\circ$ bis $\pm 12^\circ$. δ'.

$a-a'$	±6°.		±7°.		±8°.		±9°.		±10°.		±11°.		±12°.	
	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$	γ	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$
′	″	—	″	—	″	—	″	—	″	—	″	—	″	—
0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0
1	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0
2	·00	0	·00	0	·00	0	·01	0	·01	0	·01	0	·01	0
3	·01	0	·01	0	·01	0	·01	0	·01	0	·02	0	·02	0
4	·01	0	·01	0	·02	0	·02	0	·02	0	·03	0	·03	0
5	·02	0	·02	0	·03	0	·03	0	·04	0	·04	0	·04	0
6	0·03	0	0·04	0	0·04	0	0·05	0	0·05	0	0·06	0	0·06	0
7	·04	0	·05	0	·06	0	·06	0	·07	0	·08	0	·09	0
8	·06	0	·07	0	·08	0	·09	0	·10	0	·10	0	·11	0
9	·07	0	·09	0	·10	0	·11	0	·12	0	·13	0	·14	0
10	·09	0	·11	0	·12	0	·13	0	·15	0	·16	0	·18	0
11	0·11	0	0·13	0	0·15	0	0·16	0	0·18	0	0·19	0	0·21	0
12	·13	0	·15	0	·17	0	·19	0	·21	0	·23	0	·26	0
13	·15	0	·18	0	·20	0	·23	0	·25	0	·27	0	·30	0
14	·18	0	·21	0	·24	0	·27	0	·29	0	·32	0	·35	0
15	·20	0	·24	0	·27	0	·30	0	·34	0	·37	0	·40	0
16	0·23	0	0·27	0	0·31	0	0·34	0	0·38	0	0·42	0	0·45	0
17	·26	0	·30	0	·35	0	·39	0	·43	0	·47	0	·51	0
18	·29	0	·34	0	·39	0	·43	0	·48	0	·52	0	·57	0
19	·33	0	·38	0	·43	0	·48	0	·54	0	·59	0	·64	0
20	·36	0	·42	0	·48	0	·54	0	·60	0	·65	0	·71	0
21	0·40	0	0·47	0	0·53	0	0·59	0	0·66	0	0·72	0	0·78	0
22	·44	0	·51	0	·58	0	·65	0	·72	0	·79	0	·86	0
23	·48	0	·56	0	·64	0	·72	0	·79	0	·86	0	·94	0
24	·52	0	·61	0	·69	0	·77	0	·86	0	·94	0	1·02	0
25	·57	0	·66	0	·75	0	·84	0	·93	0	1·02	0	1·11	1
26	0·61	0	0·71	0	0·81	0	0·91	0	1·01	0	1·10	0	1·20	1
27	·66	0	·77	0	·88	0	·98	0	1·09	0	1·19	1	1·29	1
28	·71	0	·83	0	·94	0	1·05	0	1·17	0	1·28	1	1·39	1
29	·76	0	·88	0	1·01	0	1·13	0	1·25	0	1·37	1	1·49	1
30	·82	0	·95	0	1·08	0	1·21	0	1·34	0	1·47	1	1·60	1
31	0·87	0	1·02	0	1·16	0	1·30	0	1·43	1	1·57	1	1·71	1
32	·93	0	1·10	0	1·23	0	1·38	0	1·53	1	1·68	1	1·82	1
33	·99	0	1·15	0	1·31	0	1·47	0	1·63	1	1·78	1	1·93	1
34	1·05	0	1·22	0	1·39	0	1·56	1	1·73	1	1·89	1	2·05	1
35	1·11	0	1·29	0	1·47	0	1·65	1	1·83	1	2·00	1	2·17	1
36	1·18	0	1·37	0	1·56	0	1·74	1	1·93	1	2·12	1	2·30	1
37	1·24	0	1·45	0	1·65	0	1·84	1	2·04	1	2·24	1	2·43	1
38	1·31	0	1·53	0	1·74	1	1·95	1	2·16	1	2·36	1	2·56	1
39	1·38	0	1·60	0	1·83	1	2·05	1	2·27	1	2·48	1	2·70	1
40	1·45	0	1·68	0	1·92	1	2·16	1	2·39	1	2·62	1	2·84	1
41	1·53	0	1·77	0	2·02	1	2·26	1	2·51	1	2·74	1	2·98	1
42	1·60	0	1·86	0	2·12	1	2·37	1	2·63	1	2·88	1	3·13	1
43	1·68	0	1·95	1	2·22	1	2·49	1	2·76	1	3·02	1	3·28	1
44	1·76	0	2·05	1	2·33	1	2·61	1	2·89	1	3·16	1	3·44	2
45	1·84	0	2·14	1	2·44	1	2·73	1	3·02	1	3·30	1	3·59	2
46	1·92	0	2·23	1	2·54	1	2·85	1	3·16	1	3·46	2	3·76	2
47	2·00	0	2·33	1	2·66	1	2·98	1	3·30	1	3·61	2	3·92	2
48	2·09	0	2·43	1	2·77	1	3·10	1	3·44	1	3·76	2	4·09	2
49	2·18	0	2·53	1	2·89	1	3·23	1	3·58	1	3·92	2	4·26	2
50	2·27	0	2·64	1	3·01	1	3·37	1	3·73	1	4·08	2	4·44	2
51	2·36	0	2·74	1	3·13	1	3·50	1	3·88	1	4·25	2	4·62	2
52	2·45	0	2·85	1	3·25	1	3·64	1	4·04	1	4·42	2	4·80	2
53	2·55	0	2·96	1	3·38	1	3·78	1	4·19	2	4·59	2	4·99	2
54	2·65	0	3·08	1	3·51	1	3·93	1	4·35	2	4·76	2	5·18	2
55	2·74	1	3·19	1	3·64	1	4·08	1	4·51	2	4·94	2	5·37	2
56	2·85	1	3·31	1	3·77	1	4·22	1	4·68	2	5·12	2	5·57	2
57	2·95	1	3·43	1	3·91	1	4·38	1	1·85	2	5·31	2	5·77	3
58	3·05	1	3·55	1	4·05	1	4·53	1	5·02	2	5·50	2	5·97	3
59	3·16	1	3·68	1	4·19	1	4·69	2	5·19	2	5·68	2	6·18	3
60	3·27	1	3·80	1	4·33	1	4·85	2	5·37	2	5·88	2	6·39	3

$\delta = \pm 12°$ bis $\pm 18°$.

δ'.

$a-a'$.	±12°.		±13°.		±14°.		±15°.		±16°.		±17°.		±18°.	
	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log\frac{\cos\delta}{\cos(\delta-\gamma)}$.
′	″	—	″	—	″	—	″	—	″	—	″	—	″	—
0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0
1	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0
2	·01	0	01	0	·01	0	·01	0	·01	0	·01	0	·01	0
3	·02	0	·02	0	·02	0	·02	0	·02	0	·02	0	·02	0
4	·03	0	·03	0	·03	0	·03	0	·04	0	·04	0	·04	0
5	·04	0	·05	0	·05	0	·05	0	·06	0	·06	0	·06	0
6	0·06	0	0·06	0	0·07	0	0·08	0	0·08	0	0·09	0	0·09	0
7	·09	0	·10	0	·10	0	·10	0	·11	0	·12	0	·13	0
8	·11	0	·12	0	·13	0	·14	0	·15	0	·16	0	·16	0
9	·14	0	·16	0	·17	0	·18	0	·19	0	·20	0	·21	0
10	·18	0	·20	0	·20	0	·22	0	·23	0	·25	0	·26	0
11	0 21	0	0·23	0	0·25	0	0·27	0	0·28	0	0·30	0	0 31	0
12	26	0	28	0	·30	0	·32	0	·33	0	·35	0	·37	0
13	·30	0	·33	0	·35	0	·37	0	·39	0	·41	0	·43	0
14	·35	0	·38	0	·40	0	·42	0	·45	0	·47	0	·50	0
15	·40	0	·43	0	·46	0	·49	0	52	0	·55	0	·58	0
16	0·45	0	0·48	0	0·52	0	0·55	0	0·59	0	0 62	0	0·66	0
17	51	0	·55	0	·59	0	·63	0	·67	0	·70	0	·74	1
18	·57	0	·61	0	·66	0	·70	0	·75	0	·79	1	·83	1
19	·64	0	·69	0	·74	0	·78	0	·83	1	·88	1	·93	1
20	·71	0	·76	0	·82	0	·87	1	·92	1	·97	1	1·03	1
21	0·78	0	0·84	0	0·90	0	0·96	1	1·02	1	1·07	1	1·13	1
22	·86	0	·92	0	·99	1	1·05	1	1·12	1	1·18	1	1·24	1
23	·94	0	1·01	1	1 08	1	1·15	1	1·22	1	1·29	1	1·36	1
24	1·02	0	1·10	1	1·18	1	1·25	1	1·33	1	1 40	1	1·48	1
25	1·11	1	1·20	1	1·28	1	1·36	1	1·44	1	1·52	1	1·60	1
26	1·20	1	1·29	1	1·38	1	1·47	1	1·56	1	1·62	1	1 73	1
27	1·29	1	1·39	1	1·49	1	1·59	1	1·69	1	1·78	1	1·87	1
28	1·39	1	1·50	1	1·61	1	1·71	1	1·81	1	1·91	1	2·01	1
29	1·49	1	1·61	1	1·72	1	1·83	1	1·94	1	2·05	1	2·16	1
30	1·60	1	1·72	1	1·84	1	1·96	1	2·08	1	2·20	1	2·31	2
31	1·71	1	1 84	1	1·97	1	2·10	1	2·22	1	2·34	1	2·47	2
32	1·82	1	1·96	1	2 10	1	2·23	1	2·37	1	2·50	2	2·63	2
33	1·93	1	2·08	1	2·23	1	2·38	1	2 52	2	2·65	2	2·79	2
34	2·05	1	2·21	1	2.37	1	2·52	1	2·67	2	2·82	2	2·97	2
35	2·17	1	2·34	1	2·51	1	2·67	2	2·83	2	2·98	2	3·14	2
36	2·30	1	2·48	1	2·65	1	2·82	2	3·00	2	3·16	2	3·32	2
37	2·43	1	2 62	1	2·80	1	2 98	2	3·16	2	3·34	2	3·51	2
38	2·56	1	2·76	1	2·96	2	3·15	2	3·34	2	3·52	2	3·70	3
39	2·70	1	2·91	1	3·12	2	3·32	2	3·52	2	3·71	2	3·90	3
40	2·84	1	3 06	2	3 28	2	3·49	2	3·70	2	3·90	3	4·10	3
41	2·98	1	3 21	2	3·44	2	3·67	2	3·89	2	4·10	3	4·31	3
42	3·13	1	3·37	2	3·61	2	3 84	2	4·08	2	4·30	3	4·52	3
43	3·28	1	3·53	2	3·79	2	4·03	2	4·27	3	4·50	3	4·74	3
44	3·44	2	3 70	2	3·97	2	4·22	2	4·48	3	4·72	3	4·97	3
45	3·59	2	3·87	2	4 15	2	4·42	2	4·68	3	4·94	3	5·19	4
46	3·76	2	4·04	2	4·33	2	4·61	3	4 89	3	5·16	3	5·43	4
47	3·92	2	4·22	2	4 53	2	4·82	3	5·11	3	5·39	3	5·67	4
48	4·09	2	4·40	2	4 72	2	5·02	3	5·33	3	5·62	4	5·91	4
49	4·26	2	4·59	2	4·92	3	5·24	3	5·55	3	5·86	4	6·16	4
50	4·44	2	4 78	2	5·12	3	5·45	3	5·78	3	6·10	4	6·41	4
51	4·62	2	4·98	2	5·33	3	5 67	3	6·01	4	6·34	4	6·67	5
52	4·80	2	5·17	3	5·54	3	5·89	3	6·25	4	6·60	4	6 94	5
53	4 99	2	5·37	3	5·75	3	6·12	3	6·50	4	6·85	4	7·20	5
54	5·18	2	5 58	3	5·97	3	6·36	4	6·74	4	7·11	5	7·48	5
55	5 37	2	5·78	3	6 20	3	6 60	4	6·99	4	7·38	5	7·76	5
56	5·57	2	6·00	3	6·42	3	6·84	4	7·25	4	7·64	5	8·04	5
57	5·77	3	6·22	3	6 66	3	7 08	4	7·51	5	7·92	5	8·33	6
58	5 97	3	6 43	3	6·89	4	7·34	4	7·78	5	8·20	5	8·63	6
59	6·18	3	6·66	3	7·13	4	7·59	4	8·05	5	8·49	5	8·93	6
60	6·39	3	6·88	3	7·37	4	7·84	4	8·32	5	8·78	6	9·23	6

$\delta = \pm 18°$ bis $\pm 24°$. δ'.

$\alpha - \alpha'$.	±18°.		±19°.		±20°.		±21°.		±22°.		±23°.		±24°.	
	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.
′	″	—	″	—	″	—	″	—	″	—	″	—	″	—
0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0
1	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0	·00	0
2	·01	0	·01	0	·01	0	·01	0	·01	0	·01	0	·01	0
3	·02	0	·02	0	·03	0	·03	0	·03	0	·03	0	·03	0
4	·04	0	·04	0	·04	0	·04	0	·05	0	·05	0	·05	0
5	·06	0	·07	0	·07	0	·07	0	·08	0	·08	0	·08	0
6	0·09	0	0·09	0	0·10	0	0·10	0	0·11	0	0·11	0	0·12	0
7	·13	0	·13	0	·14	0	·14	0	·15	0	·16	0	·16	0
8	·16	0	·17	0	·18	0	·19	0	·19	0	·20	0	·21	0
9	·21	0	·22	0	·23	0	·24	0	·25	0	·26	0	·26	0
10	·26	0	·27	0	·28	0	·29	0	·30	0	·31	0	·32	0
11	0·31	0	0·32	0	0·34	0	0·35	0	0·37	0	0·38	0	0·39	0
12	·37	0	·38	0	·40	0	·42	0	·44	0	·46	0	·47	1
13	·43	0	·45	0	·47	0	·49	0	·51	0	·53	1	·55	1
14	·50	0	·52	0	·55	0	·57	0	·59	1	·61	1	·64	1
15	·58	0	·60	0	·63	1	·66	1	·68	1	·70	1	·73	1
16	0·66	0	0·69	1	0·72	1	0·75	1	0·78	1	0·81	1	0·83	1
17	·74	1	·77	1	·81	1	·84	1	·88	1	·91	1	·94	1
18	·83	1	·87	1	·91	1	·95	1	·98	1	1·01	1	1·05	1
19	·93	1	·97	1	1·01	1	1·05	1	1·09	1	1·13	1	1·17	1
20	1·03	1	1·08	1	1·12	1	1·16	1	1·21	1	1·26	1	1·30	1
21	1·13	1	1·18	1	1·24	1	1·29	1	1·34	1	1·38	1	1·43	1
22	1·24	1	1·30	1	1·36	1	1·42	1	1·47	1	1·52	1	1·57	1
23	1·36	1	1·42	1	1·48	1	1·54	1	1·60	1	1·66	1	1·72	2
24	1·48	1	1·55	1	1·62	1	1·68	1	1·75	2	1·81	2	1·87	2
25	1·60	1	1·67	1	1·75	1	1·82	2	1·89	2	1·96	2	2·03	2
26	1·73	1	1·82	1	1·90	2	1·98	2	2·05	2	2·12	2	2·19	2
27	1·87	1	1·96	1	2·04	2	2·12	2	2·21	2	2·28	2	2·36	2
28	2·01	1	2·10	2	2·20	2	2·29	2	2·38	2	2·46	2	2·54	2
29	2·16	1	2·26	2	2·36	2	2·46	2	2·55	2	2·64	2	2·73	3
30	2·31	2	2·42	2	2·52	2	2·62	2	2·73	2	2·83	3	2·92	3
31	2·47	2	2·58	2	2·70	2	2·80	2	2·91	2	3·02	3	3·12	3
32	2·63	2	2·75	2	2·87	2	2·98	2	3·10	3	3·21	3	3·32	3
33	2·79	2	2·92	2	3·05	2	3·18	3	3·30	3	3·42	3	3·53	3
34	2·97	2	3·10	2	3·24	3	3·37	3	3·50	3	3·62	3	3·75	4
35	3·14	2	3·29	2	3·44	3	3·57	3	3·71	3	3·84	3	3·97	4
36	3·32	2	3·48	2	3·63	3	3·78	3	3·94	3	4·07	4	4·20	4
37	3·51	2	3·68	3	3·84	3	4·00	3	4·15	4	4·30	4	4·44	4
38	3·70	2	3·88	3	4·05	3	4·22	3	4·38	4	4·53	4	4·68	4
39	3·90	3	4·09	3	4·27	3	4·44	4	4·61	4	4·77	4	4·93	5
40	4·10	3	4·30	3	4·49	3	4·67	4	4·85	4	5·02	4	5·19	5
41	4·31	3	4·51	3	4·71	4	4·90	4	5·10	4	5·28	5	5·45	5
42	4·52	3	4·74	3	4·95	4	5·15	4	5·35	5	5·54	5	5·72	5
43	4·74	3	4·96	4	5·19	4	5·40	4	5·60	5	5·80	5	6·00	6
44	4·97	3	5·20	4	5·43	4	5·65	5	5·87	5	6·08	5	6·28	6
45	5·19	4	5·44	4	5·68	4	5·91	5	6·14	5	6·36	6	6·57	6
46	5·43	4	5·68	4	5·93	5	6·17	5	6·41	5	6·63	6	6·86	6
47	5·67	4	5·94	4	6·20	5	6·45	5	6·70	6	6·93	6	7·16	7
48	5·91	4	6·18	4	6·46	5	6·72	5	6·98	6	7·23	6	7·47	7
49	6·16	4	6·44	5	6·73	5	7·00	6	7·28	6	7·53	7	7·78	7
50	6·41	4	6·71	5	7·01	5	7·30	6	7·58	6	7·84	7	8·11	8
51	6·67	5	6·98	5	7·29	6	7·58	6	7·88	7	8·16	7	8·43	8
52	6·94	5	7·26	5	7·58	6	7·89	6	8·20	7	8·48	8	8·77	8
53	7·20	5	7·54	5	7·88	6	8·20	7	8·51	7	8·81	8	9·11	9
54	7·48	5	7·83	6	8·18	6	8·51	7	8·84	8	9·15	8	9·46	9
55	7·76	5	8·12	6	8·48	6	8·82	7	9·17	8	9·49	8	9·81	9
56	8·04	5	8·42	6	8·80	7	9·15	7	9·50	8	9·84	9	10·17	10
57	8·33	6	8·72	6	9·11	7	9·48	8	9·85	8	10·19	9	10·53	10
58	8·63	6	9·04	7	9·44	7	9·82	8	10·20	9	10·56	9	10·91	10
59	8·93	6	9·34	7	9·76	8	10·15	8	10·55	9	10·92	10	11·29	11
60	9·23	6	9·66	7	10·10	8	10·50	9	10·91	9	11·29	10	11·67	11

$\delta = \pm 24°$ bis $\pm 28°$. δ'.

$a-a'$.	±24°.		±25°.		±26°.		±27°.		±28°.	
	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.	γ.	$\log \frac{\cos\delta}{\cos(\delta-\gamma)}$.
′	″	—	″	—	″	—	″	—	″	—
0	0·00	0	0·00	0	0·00	0	0·00	0	0·00	0
1	·00	0	·00	0	·00	0	·00	0	·00	0
2	·01	0	·01	0	·01	0	·01	0	·01	0
3	·03	0	·03	0	·03	0	·03	0	·03	0
4	·05	0	·06	0	·06	0	·06	0	·06	0
5	·08	0	·09	0	·09	0	·09	0	·09	0
6	0·12	0	0·12	0	0·12	0	0·13	0	0·13	0
7	·16	0	·17	0	·17	0	·18	0	·18	0
8	·21	0	·22	0	·22	0	·22	0	·22	0
9	·26	0	·27	0	·28	0	·29	0	·29	0
10	·32	0	·33	0	·34	0	·35	0	·36	0
11	0·39	0	0·40	0	0·42	0	0·43	0	0·44	1
12	·47	0	·48	0	·50	1	·51	1	·52	1
13	·55	1	·57	1	·58	1	·59	1	·61	1
14	·64	1	·66	1	·67	1	·69	1	·71	1
15	·73	1	·75	1	·77	1	·79	1	·81	1
16	0·83	1	0·86	1	0·88	1	0·90	1	0·93	1
17	·94	1	·97	1	·99	1	1·02	1	1·04	1
18	1·05	1	1·08	1	1·11	1	1·14	1	1·17	1
19	1·17	1	1·20	1	1·24	1	1·27	1	1·30	1
20	1·30	1	1·34	1	1·38	1	1·41	2	1·45	2
21	1·43	1	1·47	1	1·52	2	1·55	2	1·59	2
22	1·57	1	1·62	2	1·66	2	1·70	2	1·75	2
23	1·72	2	1·77	2	1·82	2	1·87	2	1·91	2
24	1·87	2	1·92	2	1·98	2	2·03	2	2·08	2
25	2·03	2	2·09	2	2·15	2	2·20	2	2·26	3
26	2·19	2	2·26	2	2·32	2	2·38	3	2·45	3
27	2·36	2	2·44	2	2·51	3	2·57	3	2·64	3
28	2·54	2	2·62	3	2·70	3	2·77	3	2·84	3
29	2·73	3	2·81	3	2·89	3	2·96	3	3·03	3
30	2·92	3	3·00	3	3·09	3	3·17	3	3·26	4
31	3·12	3	3·21	3	3·30	3	3·39	4	3·48	4
32	3·32	3	3·42	3	3·52	4	3·61	4	3·70	4
33	3·53	3	3·63	4	3·74	4	3·84	4	3·94	4
34	3·75	4	3·86	4	3·97	4	4·07	4	4·18	5
35	3·97	4	4·09	4	4·21	4	4·32	5	4·43	5
36	4·20	4	4·33	4	4·46	5	4·58	5	4·69	5
37	4·44	4	4·57	5	4·71	5	4·83	5	4·95	6
38	4·68	4	4·82	5	4·96	5	5·09	5	5·22	6
39	4·93	5	5·08	5	5·23	5	5·36	6	5·50	6
40	5·19	5	5·34	5	5·50	6	5·65	6	5·79	6
41	5·45	5	5·61	6	5·78	6	5·93	6	6·08	7
42	5·72	5	5·90	6	6·07	6	6·22	7	6·38	7
43	6·00	6	6·18	6	6·36	7	6·52	7	6·69	7
44	6·28	6	6·47	6	6·66	7	6·83	7	7·00	8
45	6·57	6	6·77	7	6·96	7	7·14	8	7·32	8
46	6·86	6	7·07	7	7·28	7	7·46	8	7·65	9
47	7·16	7	7·38	7	7·60	8	7·80	8	7·99	9
48	7·47	7	7·69	8	7·92	8	8·12	9	8·33	9
49	7·79	7	8·02	8	8·26	8	8·47	9	8·68	10
50	8·11	8	8·35	8	8·60	9	8·82	9	9·04	10
51	8·43	8	8·68	9	8·94	9	9·18	10	9·41	11
52	8·77	8	9·03	9	9·30	9	9·54	10	9·78	11
53	9·11	9	9·39	9	9·66	10	9·91	11	10·16	11
54	9·45	9	9·74	10	10·08	10	10·29	11	10·55	12
55	9·81	9	10·11	10	10·40	11	10·67	11	10·94	12
56	10·17	10	10·47	10	10·78	11	11·06	12	11·34	13
57	10·53	10	10·85	11	11·17	11	11·46	12	11·75	13
58	10·91	10	11·24	11	11·57	12	11·87	13	12·17	13
59	11·29	11	11·63	12	11·97	12	12·28	13	12·59	14
60	11·67	11	12·02	12	12·38	13	12·70	14	13·02	15

RESEARCHES ON THE ANNUAL PARALLAX OF THE STAR GROOMBRIDGE, 1618.

By Professor Robert S. Ball, LL.D., F.R.S., Royal Astronomer of Ireland.

This star is No. 89 of Argelander's list of stars with large proper motion (Bonn Obs., Vol. VII., p. 69). It is +50°, 1725 in the Durchmusterung, where its magnitude is given as 6·8. The position of the star at the Epoch 1878·0 is found from meridian observations at Washington in 1871, and Radcliffe observations in 1859 to be R A$=10^{h}\ 3^{m}\ 53^{s}{\cdot}73$ $\delta=50^{\circ}\ 4'\ 13''{\cdot}9$, allowance having been made for the proper motions.

According to Argelander (l.c., p. 110) the proper motion in R A is $-0^{s}{\cdot}1390$, and in declination $-0''{\cdot}501$. This corresponds to an arcual motion of $1''{\cdot}429$ per annum, the position angle of the motion being 249° 29′, *i.e.*, this is the position angle of the place of the star next year from the present place.

The distance and position of the star +50°, 1724 (8·8 mag.) has been measured with the view of ascertaining the parallax of Gr. 1618. It will be in the first place of importance to show that the comparison star does not share in the proper motion of Gr. 1618.

This will appear most clearly by a comparison of the recent observations with those made by Argelander on March 21st, 1843, as reduced in Argelander-Oeltzen to the Epoch 1842·0. From an approximate reduction of my observations, I conclude that at the Epoch 1878·0 the distance of +50°, 1724 from Gr. 1618 is $198''{\cdot}1$, and the position angle is 201° 42′·8. From this I find—

$$\Delta\alpha=\ 7^{s}{\cdot}603.$$
$$\Delta\delta=184''{\cdot}1.$$

But from Argelander-Oeltzen we have—

$$\Delta\alpha=\ 12^{s}{\cdot}4.$$
$$\Delta\delta=203''{\cdot}9.$$

We apply to these differences the annual proper motion of Gr. 1618—viz., $-0^{s}{\cdot}1390$ in R A, and $-0''{\cdot}501$ in declination. During the thirty-five years that have elapsed since his observations the corrections will amount to $-4^{s}{\cdot}87$ and $-17''{\cdot}5$ respectively. We therefore have for the differences in 1878—

$$\Delta\alpha=\ 7{\cdot}5.$$
$$\Delta\delta=186''{\cdot}4.$$

It is therefore evident that +50°,1724 cannot have a proper motion which even in thirty-five years amounts to much more than $0^{s}{\cdot}2$ in R A or $2''{\cdot}3$ in decl. Compared with the large proper motion of Gr. 1618, we may neglect these quantities. As a first approximation we therefore conclude that the absolute proper motion assigned by Argelander to Gr. 1618 coincides with its proper motion relatively to the comparison star +50°, 1724.

The annual decrement of the distance from Gr. 1618 to +50°,1724 in consequence of the proper motion of the former is $0''{\cdot}9579$. By the same reason the position angle of +50°,1724 from Gr. 1618 decreases at the rate of 18′·398 annually.

In the first series of observations now to be discussed, measurements were made on fifty-five nights, both of distance and position. In the present paper the measurements of the distance alone are discussed.

The following table contains the observations of the distance corrected in the usual manner for the effects of refraction, and reduced to the Epoch 1878·0. The corrections for proper motion have, however, not yet been applied :—

CORRECTED DISTANCES OF +50°, 1724 FROM GR. 1618.

Date.	Dist.	Date.	Dist.	Date.	Dist.	Date.	Dist.
1878.		1878.		1878.		1878.	
March 4,	198″·381	April 1,	198″·537	July 8,	197″·812	Nov. 19,	197″·949
„ 13,	198·542	„ 1,	198·493	„ 12,	197·806	„ 25,	198·059
„ 13,	198·459	„ 6,	198·461	„ 21,	197·743	„ 28,	198·105
„ 15,	198·370	„ 17,	198·353	„ 28,	197·795	Dec. 1,	198·303
„ 18,	198·484	„ 21,	198·415	„ 30,	197·999	„ 5,	198·063
„ 18,	198·581	„ 24,	198·507	„ 31,	197·751	„ 8,	198·337
„ 21,	198·537	„ 27,	198·261	Aug. 2,	197·892		
„ 21,	198·499	May 3,	198·327	„ 10,	198·047	1879.	
„ 22,	198·450	„ 5,	198·382	Sept. 20,	197·869	Jan. 8,	198·088
„ 24,	198·783	„ 9,	198·741	„ 23,	198·221	Feb. 5,	197·958
„ 24,	198·753	„ 18,	198·355	„ 25,	198·029	„ 22,	197·993
„ 25,	198·484	„ 20,	198·492	Oct. 24,	197·830	„ 25,	198·142
„ 29,	198·493	„ 21,	198·364	„ 28,	198·195	„ 28,	198·184
„ 29,	198·605	„ 28,	198·232	Nov. 1,	197·858	Mar. 19,	198·213
„ 31,	198·445	July 1,	198·330	„ 8,	197·970	„ 31,	197·819
„ 31,	198·460	„ 7,	197·951	„ 17,	197·799	April 2,	197·578

The mean of the observed distances is 198″·22474. The mean date of the observations is 1878·559621. The correction to be applied for proper motion corresponding to the interval between the Epoch and the mean date is +0″·53604. The adopted mean distance at the Epoch is accordingly 198″·76078.

In retaining five places of decimals in the adopted mean distance, it is not of course pretended that the observations are worthy of such refinement. One or two places would be quite sufficient, so far as the accuracy of the observations are concerned. In dealing with such a mass of figures it is, however, necessary to retain every check which can be devised upon the numerical accuracy. This is especially true in the absolute terms of the equations of condition. The absolute terms cannot be verified by projection in a curve in the manner which is so convenient for the coefficients. The sum of the absolute terms must, however, be zero ; this cannot be expected to be fulfilled accurately to three places unless the calculations of the mean position be effected to five places.

It is convenient to denote by D the observed distance of the two stars merely evaluated in seconds of arc. When the correction for refraction and reduction have been applied, we denote the distance by D'. When further the correction for the assumed proper motion has been applied the distance becomes D''. The mean of all the values of D' is D_0', while when the correction for proper motion is applied D_0' becomes D_0'', the adopted mean distance at the Epoch.

Suppose that there are m observations at the dates $b_1, b_2, \ldots b_m$, while the mean date is b_0. Let the annual value of the proper motion be ϵ, then we have—

$$nb_0 = \Sigma b_1.$$

We have also—

$$D_1'' = D_1' + b_1\epsilon$$

whence—

$$\Sigma D_1'' = \Sigma D_1' + mb_0\epsilon$$
$$= mD_0'',$$

but if n be the absolute term of the equation of condition then—

$$n = D_1'' - D_0'',$$

whence we have –

$$\Sigma n = 0.$$

There are four unknowns in the equation of condition:—

x with its sign changed is the correction which is to be applied to the assumed distance at the Epoch.

x' is the correction to the assumed annual value of the proper motion, so that the true value of the annual proper motion in distance is $+(0''\cdot9579+x')$.

π is the annual parallax of Gr. 1618.

κ is a possible difference between the coefficients of aberration for the two stars.

In the co-efficients the quantities b, $\odot$, R occur:—

b is the fraction of the year since the Epoch.

$\odot$ is the sun's longitude at the time of observation.

R is the sun's radius vector.

Each observation of the distance gives an equation of condition of the following form—

$$x+bx'-0''\cdot5817\ \text{R}\cos(\odot-319^\circ\ 41')\pi-0''\cdot5817\sin(\odot-319^\circ\ 41')\kappa+D''-D_0''=0.$$

The coefficients of the four unknowns can be easily verified. Their sum is taken as an ordinate with the time as an abscissa, and plotted in a curve. By this precaution, together with that of the sums of the absolute terms being zero, the calculation of the equations of condition is rendered free from uncertainty. Lithographed forms are employed in this as well as in other portions of the calculation.

The following are sixty-two equations of condition derived from the observations made on fifty-five nights. The column headed residuals contains the result found when the values of the unknowns are substituted in the left-hand side of the equations. A complete observation consists of eight readings of each of the micrometer screws. Half of these are taken with the wires crossed. Half are also made with the micrometer turned through 180° from its original position. These measures are then reduced, using the thermometric value of the micrometer screws found by Dr. Brünnow (Dunsink Observations, Part I.). In two cases only half a complete series of measures has been secured; under these circumstances a weight of $\frac{1}{2}$ is attached to the observations when they are being introduced into the normal equations:—

GROOMBRIDGE, 1618 AND + 50°, 1724.

Equations of Condition from Distances.

No.					Residuals.	Weight.
1	x +·1713x'	−·5245π	−·2428κ	−·216 = 0	−·464	1
2	+·1959	−·4815	−·3225	−·031	−·237	1
3	+·1960	−·4813	−·3229	−·114	−·320	1
4	+·2013	−·4706	−·3387	−·198	−·394	1
5	+·2096	−·4525	−·3633	−·076	−·258	1
6	+·2097	−·4522	−·3637	+·021	−·161	1
7	+·2179	−·4332	−·3867	−·015	−·182	1
8	+·2180	−·4330	−·3869	−·053	−·220	1
9	+·2204	−·4272	−·3935	−·100	−·262	1
10	+·2258	−·4138	−·4078	+·239	+·086	1
11	+·2260	−·4134	−·4083	+·209	+·057	1
12	+·2287	−·4063	−·4155	−·058	−·206	1
13	+·2396	−·3776	−·4422	−·038	−·168	1
14	+·2398	−·3768	−·4429	+·074	−·054	1
15	+·2451	−·3623	−·4550	−·081	−·200	1
16	+·2453	−·3615	−·4557	−·066	−·184	1
17	+·2478	−·3546	−·4614	+·014	−·100	1
18	+·2479	−·3542	−·4615	−·030	−·144	1
19	+·2614	−·3144	−·4897	−·049	−·138	1
20	+·2916	−·2175	−·5399	−·129	−·166	1
21	+·3026	−·1803	−·5534	−·056	−·075	1
22	+·3108	−·1519	−·5618	+·044	+·039	1
23	+·3190	−·1230	−·5687	−·194	−·186	1
24	+·3352	−·0649	−·5781	−·113	−·080	1
25	+·3407	−·0452	−·5799	−·052	−·010	1
26	+·3516	−·0056	−·5817	+·317	+·375	1
27	+·3765	+·0838	−·5758	−·045	+·046	1
28	+·3818	+·1028	−·5727	+·097	+·196	1
29	+·3845	+·1124	−·5710	−·029	+·072	1
30	+·4038	+·1800	−·5539	−·142	−·020	1
31	+·4969	+·4546	−·3721	+·045	+·224	½
32	+·5133	+·4901	−·3256	−·318	−·137	1
33	+·5160	+·4955	−·3175	−·455	−·274	½
34	+·5270	+·5158	−·2844	−·450	−·270	1
35	+·5515	+·5527	−·2058	−·490	−·316	1
36	+·5708	+·5730	−·1407	−·419	−·253	1
37	+·5763	+·5773	−·1218	−·210	−·049	1
38	+·5790	+·5792	−·1122	−·455	−·295	1
39	+·5845	+·5825	−·0932	−·309	−·152	1
40	+·6063	+·5891	−·0161	−·133	+·007	1
41	+·7189	+·4582	+·3604	−·203	−·200	1
42	+·7272	+·4384	+·3837	+·157	+·148	1
43	+·7327	+·4248	+·3983	−·030	−·048	1
44	+·8120	+·1798	+·5528	−·153	−·288	1
45	+·8229	+·1415	+·5640	+·223	+·073	1
46	+·8337	+·1015	+·5726	−·104	−·268	1
47	+·8531	+·0311	+·5808	+·026	−·162	1
48	+·8776	−·0592	+·5786	−·121	−·336	1
49	+·8833	−·0801	+·5760	+·034	−·187	1
50	+·8996	−·1393	+·5643	+·160	−·075	1
51	+·9078	−·1685	+·5560	+·214	−·028	1
52	+·9161	−·1973	+·5461	+·420	+·172	1
53	+·9267	−·2335	+·5312	+·190	−·065	1
54	+·9350	−·2612	+·5177	+·472	+·212	1
55	+1·0204	−·4885	+·3026	+·305	+·043	1
56	+1·0972	−·5730	+·0286	+·248	+·047	1
57	+1·1441	−·5574	−·1455	+·328	+·190	1
58	+1·1523	−·5495	−·1749	+·485	+·360	1
59	+1·1604	−·5401	−·2036	+·535	+·421	1
60	+1·2123	−·4478	−·3692	+·613	+·589	1
61	+1·2452	−·3637	−·4539	+·251	+·285	1
62	+1·2508	−·3477	−·4664	+·015	+·059	1

From these the normal equations were computed in the usual manner—

$$
\begin{aligned}
+61{\cdot}000x+34{\cdot}190x' -6{\cdot}497\pi- 9{\cdot}642\kappa +4{\cdot}111&=0.\\
+34{\cdot}190x+26{\cdot}000x' -3{\cdot}202\pi- {\cdot}3944\kappa+2{\cdot}551&=0.\\
-6{\cdot}497x- 3{\cdot}202x' +9{\cdot}029\pi+ 2{\cdot}139\kappa -3{\cdot}079&=0.\\
-9{\cdot}642x- {\cdot}3944x'+2{\cdot}139\pi+11{\cdot}634\kappa +1{\cdot}117&=0.
\end{aligned}
$$

Solving these we find—

$$
\begin{aligned}
x &=-0''{\cdot}1621\pm{\cdot}05.\\
x' &=+0''{\cdot}1534\pm{\cdot}07.\\
\pi &=+0''{\cdot}3472\pm{\cdot}05.\\
\kappa &=-0\ {\cdot}2890\pm{\cdot}06.
\end{aligned}
$$

The probable error of one complete observation is ±·15.

The sum of the squares $[n\ n]=3{\cdot}537$.

The sum of the squares $[v\ v]=2{\cdot}935$.

The result of the observations is therefore to indicate a parallax of about one-third of a second for Gr. 1618. Though the probable error of the result is only ·05, yet there are certain features which suggest the necessity of further examination. The signs of the residuals look as if some systematic irregularities had affected the measures. The large value of the unknown κ seems also somewhat improbable. The substitution of the values for the unknowns only abates the sum of the squares of the absolute terms from 3·537 to 2·935. I therefore decided to commence another series of observations in the hope that the experience already obtained would ensure a better result.

TABLE OF CORRECTED DISTANCES.

Date.	Dist.	Date.	Dist.	Date.	Dist.	Date.	Dist.
1879.		1880.		1880.		1880.	
Aug. 14, .	197″·187	Jan. 9, .	196″·985	Mar. 21, .	196″·489	May 7, .	196″·255
„ 23, .	196·846	„ 21, .	196·961	„ 22, .	196·545	„ 8, .	196·317
Oct. 28, .	197·184	Feb. 4, .	197·077	„ 22, .	196·626	„ 13, .	196·466
Nov. 1, .	196·935	„ 5, .	196·985	„ 31, .	196·924	„ 15, .	196·319
„ 11, .	197·079	Mar. 12, .	196·473	April 6, .	196·452	„ 16, .	196·577
„ 13, .	196·841	„ 15, .	196·398	„ 8, .	196·583	July 15, .	196·191
„ 30, .	197·228	„ 18, .	196·170	„ 22, .	196·517	„ 16, .	195·807
Dec. 4, .	197.056	„ 19, .	196·577	„ 24, .	196·583	„ 20, .	196·009
„ 10, .	197·177	„ 19, .	196·524	„ 25, .	196·629	„ 21, .	195·748
„ 17, .	196·970	„ 20, .	196·862	„ 27, .	196·589	„ 21, .	195·852
„ 18, .	196·817	„ 21, .	196·557	May 6, .	196·432	„ 29, .	195·757

The mean of the observed distances is 196″·60355, the mean date being 1880·188014. The correction for proper motion is + 1″·12733, and accordingly the adopted mean distance for 1879·0 is 197″·73088.

EQUATIONS OF CONDITION FROM DISTANCE.

						Residuals.	Weight.
1	x + ·6170x'	+·5887π	+·0200κ	+·042=0		+·075	1
2	+ ·6416	+·5780	+·1069	—·276		—·242	1
3	+ ·8233	+·1428	+·5637	+·234		+·171	1
4	+ ·8340	+·1036	+·5723	--·005		—·079	1
5	+ ·8614	+·0032	+·5817	+·166		+·067	1
6	+ ·8667	— ·0162	+·5815	—·068		—·172	1
7	+ ·9131	—·1843	+·5509	+·364		+·223	1
8	+ ·9242	—·2227	+·5360	+·202		+·053	1
9	+ ·9407	—·2775	+·5089	+·339		+·179	1
10	+ ·9600	—·3377	+·4696	+·150		—·022	1
11	+ ·9625	—·3452	+·4640	—·001		—·174	1
12	+1·0233	—·4928	+·2956	+·225		+·033	1
13	+1·0561	—·5435	+·1831	+·232		+·037	1
14	+1·0941	—·5721	+·0428	+·384		+·199	1
15	+1·0967	—·5728	+·0330	+·295		+·111	1
16	+1·1960	—·4841	—·3185	—·123		—·233	1
17	+1·2035	—·4687	—·3415	—·191		—·292	1
18	+1·2117	—·4508	--·3656	—·411		—·503	1
19	+1·2151	—·4432	—·3750	—·001		—·088	1
20	+1·2152	—·4430	—·3752	—·054		—·141	1
21	+1·2178	—·4367	—·3827	+·287		+·202	1
22	+1·2199	—·4317	—·3885	—·016		—·098	1
23	+1·2205	—·4302	—·3902	—·084		—·166	1
24	+1·2227	—·4250	—·3960	--·026		—·104	1
25	+1·2233	—·4235	—·3976	+·056		—·021	1
26	+1·2479	—·3581	—·4584	+·377		+·332	1
27	+1·2643	—·3095	—·4929	—·079		—·103	1
28	+1·2697	--·2930	—·5030	+·057		+·040	1
29	+1·3080	—·1661	—·5578	+·027		+·066	1
30	+1·3134	—·1473	—·5630	+·098		+·145	1
31	+1·3162	—·1377	—·5654	+·147		+·198	1
32	+1·3215	—·1188	—·5697	+·112		+·171	1
33	+1·3463	—·0301	—·5810	—·021		+·075	1
34	+1·3491	—·0198	— ·5814	—·196		—·095	½
35	+1·3516	—·0106	—·5817	—·131		—·027	1
36	+1·3651	+·0385	—·5805	+·030		+·154	1
37	+1·3709	+·0590	—·5788	—·111		+·021	1
38	+1·3736	+·0685	--·5778	+·150		+·286	1
39	+1·5378	+·5316	—·2547	—·081		+·242	½
40	+1·5406	+·5358	—·2460	—·462		—·138	1
41	+1·5516	+·5511	—·2101	—·250		+·082	1
42	+1·5541	+·5543	—·2017	—·508		—·175	1
43	+1·5543	+·5545	—·2012	—·404		—·071	1
44	+1·5762	+·5762	—·1269	—·478		—·134	1

NORMAL EQUATIONS.

+43·000x	+50·829x'	—4·963π	— 6·235κ	+ ·136=0
+50·829	+62·535	—5·164	—10·420	— ·983=0
— 4·963	— 5·164	+6·353	+ ·994	—2·078=0
— 6·235	—10·420	+ ·994	+ 8·204	+1·183=0

Solving these we find the following values :—

$x = -0''\cdot3532 \pm \cdot133$

$x' = +0\ \cdot3222 \pm \cdot116$

$\pi = +0\ \cdot3196 \pm \cdot052$

$\kappa = -0\ \cdot0422 \pm \cdot066$

The probable error of one observation is ±·119.

The sum of the squares $[n\ n] = 2\cdot330$.

The sum of the squares $[v\ v] = 1\cdot255$.

These observations are free from the features which appeared to me to be objectionable in the former series. On the other hand it is to be observed that the corrections to the proper motion and to the assumed mean distance now attain considerable amounts. This is, I believe, partly due to the choice of an Epoch, which is more than a year from the mean date of the observations. To examine the plausibility of these corrections, I have combined the results of the two series of observations taking account of their probable errors. I thus find—

$$x = -0''{\cdot}1858 \pm {\cdot}047.$$
$$x' = +0''{\cdot}1985 \pm {\cdot}060.$$
$$\pi = +0''{\cdot}3339 \pm {\cdot}036.$$
$$\kappa = -0''{\cdot}1774 \pm {\cdot}044.$$

These results do not appear to be at all improbable. A positive correction to the proper motion is indeed indicated by the adopted mean distances at the Epochs of 1878 and 1879. These are respectively 198″·7608 and 197″·7308. This corresponds to a proper motion in the distance of somewhat over a second per annum, while the assumed proper motion is somewhat less than a second; nearly half of the value of x' is thus accounted for.

I believe that these observations render the existence of a parallax of about one-third of a second tolerably certain. It will not, however, be possible to determine the parallax definitely until further investigations have been made. Measurements of the position angle of the comparison star from Gr. 1618 are very well adapted for this purpose. Indeed the parallax has a much larger effect upon the position angle than it has upon the distance. I have made such measurements at the same time as the measurements of distance which are here discussed. These observations are not yet ready for publication. I may, however, say that though some difficulties have been met with, yet the position angle observations as a whole tend to confirm the fact that Gr. 1618 has a parallax sufficiently large to entitle it to a place among the sun's nearest neighbours.

Dunsink Observatory,
22 Decr., 1880.

DETERMINATIONS OF THE LUNAR RADIANT HEAT DURING THE PROGRESS OF AN ECLIPSE. By the Earl of Rosse.

During the years 1868, '69 and '70 I made some experiments with the thermopile, with the view of ascertaining how far it was possible to detect and measure the amount of heat radiated to the earth from the moon. I showed[*] that it was possible to form a rough estimate of its amount, and I compared its amount with the heat coming to us from the sun. I showed that it varied much in quantity with the position of the moon, being, with my apparatus, inappreciable near new moon, and increasing to a maximum at or near full moon; that in fact it was heat which had fallen upon the moon from the sun, not heat from the interior of the moon. I also showed that though the heat which I had measured had its immediate origin in the sun, it was veritable radiant heat from the moon's surface, having been in great part first absorbed by the lunar surface, and afterwards radiated from it, much lowered in mean refrangibility.

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[*] Proc. Roy. Soc., 1869 and 1870.

A more extended series of determinations were made by Dr. Copeland in 1871 and 1872. These fully confirmed the previous results, and when carefully and fully reduced by him, gave with tolerable accuracy the law of variation of the radiant heat with the phase.

On comparing the heat curve between new and full moon with that between full and new moon, however, it was not found as might have been expected, that during the latter period there was an unmistakable preponderance over that during the former period, which could be ascribed to the lapse of time necessary for the lunar surface to acquire the temperature due to the radiation then falling upon it; on the contrary, the small preponderance of heat noticed at the third quarter over that at the first quarter, like the circumstance of the occurence of the maximum of heat rather before full moon, could with more probability be attributed to the inequalities of the lunar surface.

It therefore appeared that it would be of interest to apply a test of the rate at which the moon's surface follows the changes of radiant heat falling upon it, more decisive than that afforded by observations made at corresponding positions before and after full moon, and with that object three attempts have been made to measure the heat during the progress of a lunar eclipse.

1. On 1872, May 22, clouds entirely prevented observations during the whole duration of the partial eclipse.

2. On 1872, November 14, clouds interfered much, but from simultaneous determinations of the heat and of the light at intervals when the sky was fairly clear, it appeared that the decline and subsequent increase of heat took place as rapidly as that of the light, during the progress of the partial eclipse.*

3. On 1877, August 23, some determinations of the heat during the total eclipse were made; clouds again much interfered, but the determinations which, as lately reduced by Dr. Boeddicker, are given below, clearly show a very great decline of heat during the eclipse and a rapid rise of temperature after that the period of totality had passed.

On comparing, however, the last determination (made twenty minutes after the last contact with the penumbra) with that of the previous night, reduced to full moon, there would appear to have been still only one-third or one-fourth of the normal heat regained, and this result appears irreconcilable with the great reduction of temperature at the middle of the eclipse. It would therefore appear probable that some change of the value of the readings of the galvanometer had arisen between August 22 and August 23.

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* *See* Phil. Trans., 1873.

August 22 appears to have been the first night on which the apparatus was used after that the three-foot telescope had been remounted as an equatoreal. The thermopile apparatus was then, as it has been on every succeeding occasion up to the present time, turned in its adapting tube, so that by mere motion in declination, without touching the right ascension movement, the moon's image can be transferred from one thermopile to the other, but it had not then been noticed that the axis of the adapting tube was not parallel with the optic axis of the telescope.

By recent experiment it is found that when the apparatus is turned round, through 180° from the position for which it has been adjusted, so as to bring the other pile uppermost, the obliquity is so great that much of the heat does not fall upon the piles, and about 32·4 per cent. only of the heat is registered by the apparatus; multiplying then all the numbers for August 23, in the sixth column, by 3·06, we have the numbers in the last column (X.), which can with more certainty be compared with the determination of the previous night. It should be noted that the uncertainty as to how the determinations of August 23 can be compared with those of other nights, does not affect comparisons *inter se* of the several determinations of August 23. The galvanometer needle having been taken out and repaired since 1873, the above readings are not comparable with those published in the Philosophical Transactions for 1873. Let us hope that during the next favourable eclipse of the moon a more satisfactory series of heat determinations may be obtained.

LUNAR RADIANT HEAT

Observed during the Total Eclipse of the Moon, August 23rd, 1877.

Mean time, Greenwich.	Mean Deviation. G.	No. of Observations.	P.E.	☾'s app. Zen. Dist.	G reduced to Zenith.	Phases of Total Eclipse.	Remarks.‡	X.
Aug. 22, 12^h 25	426·2	20	± 3·15	69°·9	606·7 †		Clear.	
Aug. 23,								
9^h 41	8·7	10	± 2·91	65·5	11·4	9^h 14^m first contact with shadow.	. . . .	34·0
*	1·3	21	± 1·74	65·2	1·7	10 19 beginning of total Phase.	. . . .	5·1
12 1	7·3	9	± 3·07	65·0	9·3	12 4 end of total Phase.	Cloudy, . .	28·2
12 49	15·5	10	± 2·98	64·8	19·6	13 9 last contact with shadow,	Clouds, . .	59·9
13 39	116·9	11	± 1·58	64·6	147·2	14 19 last contact with the Penumbra.	Pretty clear, at the end light clouds.	450·5
14 40	138·1	13	± 2·98	64·4	173·3		Clear, . .	530·2

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* Exact time not noticed, but observations certainly during total Phase.

† Here reduction has also been made to full moon.

‡ The meteorological readings at 9^h 35^m m. T. Gr. were—*Bar.*, 30·099, reduced to sea level; *Therm.*, 49·0; *Humidity*, 95; *Wind*, S.W., 0·5; *Clouds*, cum. 3.

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RECHERCHES SUR L'ASTRONOMIE DES ANCIENS.

PAR H. C. F. C. SCHJELLERUP.

I. *Sur le Chronomètre Céleste d'Hipparque.*

Comment les anciens astronomes ont-ils déterminé l'heure de la nuit, et à quelle exactitude ont-ils pu parvenir ? C'est la question dont la réponse m'a occupé en composant le mémoire présent.

D'abord il faut se rappeler que l'Almageste, nonobstant que Ptolémée y avait réuni toutes les connaissances astronomiques de ses prédécesseurs, ne suffit pas en cas actuel. En effet, bien que Ptolémée, dans ce livre remarquable, ait dans beaucoup de chapitres bien arrangés, traité avec un détail minutieux tous les problèmes de l'Astronomie sphérique, et tout particulièrement les diverses espèces de temps et leur dépendance mutuelle, on regrette tout à fait le renseignement sur la question importante, de quelle manière on s'est procuré les nombreuses fixations du temps qu'on y trouve. Et ceci est d'autant plus surprenant que dans les anciens ouvrages on trouve des indications très-complètes et détaillées des differentes manières dont on s'est servi pour voir l'heure dans la vie journalière.

On possédait, d'après ces mêmes auteurs, dans l'antiquité, de grandes industries qui fournissaient le monde d'une foule de varietés des clepsydres, des sabliers et des cadrans solaires.

Ce n'est pas ici le lieu de discuter cette matière ; ceux qui désireraient en savoir davantage trouveront toute information dans l'oeuvre classique de Martini ; Abhandlung von den Sonnenuhren der Alten, Leipzig, 1777, ce qui, quoique composé, il y a cent ans, contient à peu près toutes nos connaissances sur cette matière, et dans les suppléments de Woepcke dans ses Disquisitiones Archæologico-Mathematicae circa Solaria Veterum, Berol., 1842. L'Histoire de l'Astronomie ancienne Tom. II. de Delambre nous fournit aussi des contributions de grande valeur. Quant aux clepsydres on peut lire Sallier : Recherches sur les horloges des anciens (Mém. acad. inscript. T. IV., 1723) ; voyez encore Delambre : Hist. de l'Astron. anc. T. I., p. 263, Bailly : H. de l'Astron. anc. T. I., p. 383 et suiv. Dans ces livres comme dans l'Almageste, il n'y a aucune allusion à la manière dont les anciens Astronomes se servirent pour determiner les heures de nuit.

Cependant on conçoit sans peine que, si les Astronomes avaient fait usage d'une mesure mécanique pour le temps, celle-ci fut certainement un clepsydre ou un sablier.

Nous savons déjà que l'usage des clepsydres et des sabliers remonte à une époque fort ancienne. Que les Chaldéens, ainsi que les anciens Astronomes Égyptiens, les avaient employés pour mesurer des petits intervalles du temps, on n'en peut pas douter, d'après Proclus : Hypotyposes (Halma, p. 107) où il se trouve une explication de la manière qu'ils employaient pour évaluer le diamètre du Soleil, en comparant la quantité de l'eau qui sortit à une ouverture pendant le lever du Soleil avec l'eau écoulée pendant 24 heures. Ptolémée en faisant mention de cette méthode, la rejette (Syntaxis L. V. c. 14) et il arrive au même resultat d'une autre manière toute différente.

Il est dont à présumer que les anciens Astronomes employaient les clepsydres comme aujourd'hui nous faisons usage des pendules et des chronomètres pour controler le temps pendant la nuit. La question serait donc comment ont-ils vérifié leurs indications instantaneés? Aussi sur ce sujet Ptolémée garde le silence. Il ne faudrait pas néanmoins déduire du silence de Ptolémée que l'école d'Alexandrie ne possédait aucune méthode pour régler leurs horloges à l'eau. Au contraire; Hipparque nous a laissé une méthode ingénieuse et commode, à peu près identique avec celle dont les Astronomes modernes se servent pour controler les pendules, et l'écrit où cette méthode est proposée sera l'objet de notre examen.

Seulement un des nombreux ouvrages d'Hipparque est parvenu jusqu'à nous.* Il fut publié pour la première fois en 1567 *in folio* par Petrus Victorius sous le titre : **῞Ιππαρχου Βιθυνου τῶν ᾽Αράτου καὶ Εὐδόξου φαινομένων ἐξηγήσεων βιβλία γ** (Trois Livres de Commentaires sur les Phénomènes d'Aratus et d'Eudoxe), d'après deux Manuscrits de la Biblioth. Medicœa et de la Biblioth. Vaticana. Petau en faisant une nouvelle Édition dans son Uranologion dont elle fait part dans le troisième Tome, l'a améliorée non seulement "ex conjectura" mais aussi d'après un ancien manuscrit de belle écriture conservé dans la Bibliothèque Royale.

C'est surtout un vaste recueil d'observations des levers et des couchers dont la composition a exigé d'immenses travaux occasionnés d'une critique des oeuvres sur les dits sujets par ses devanciers Aratus et Eudoxe. Il paraît que cet ouvrage est du temps qui a précédé sa découverte du mouvement des fixes en longitude, car il n'y mentionne pas que dans l'intervalle de temps écoulé depuis Eudoxe jusqu'à lui les positions des étoiles avaient pu changer relativement à l'équateur, et par suite par rapport à l'horizon. En vérité nous voyons dans la suite qu'il appartient environ à l'année 140 avant Jésus Christ.

Le troisième livre se termine dans une énumération des étoiles qui déterminent les 24 espaces horaires. Cette partie mérite une attention toute particulière, et c'est en nous appuyant seulement sur cette dernière partie du troisième livre du Commentaire d'Hipparque que nous avons composé le mémoire présent.

Ce mémoire sur une partie de l'ouvrage d'Hipparque fera d'abord connaître la nature et l'importance des travaux de ce savant Astronome, qu'on regarde avec raison comme le premier représentant de l'École d'Alexandrie. On y verra que Hipparque fut sourtout un observateur, et, qu'à ce titre, il mérite une place distinguée dans les annales de la science. D'ailleurs on avait longtemps supposé que les anciens Astronomes n'avaient rien produit de remarquable dans l'Astronomie pratique, mais ce mémoire modifiera, sur un point capital, l'opinion que l'on s'était formée des observations des anciens. Cette assertion, surtout maintenue par Delambre, est complètement renversée par le tableau que nous allons tracer des premières observations des Astronomes d'Alexandrie. Mais Delambre avait une excuse ; il ne faisait que répéter une erreur adoptée presque généralement par les savants du siècle passé ; aussi n'a-t-il pas les moyens de controler scrupuleusement les anciennes observations, envisageant les difficultés et les imperfections des ressources qui étaient à sa disposition pour faire la réduction des étoiles à une époque si éloignée.

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* Par inadvertance on dit toujours qu'on possède deux des écrits d'Hipparque. Mais le traité, *sur les constellations* (Εἰς ἀστερισμούς), réuni par P. Victorius à son édition du *Commentaire* sous le nom d'Hipparque, n'est rien que le catalogue des étoiles (sous les latitudes) de Ptolémée. D'ailleurs, cette remarque est déjà faite par Petau (Uranol. Praef.).

D'abord nous donnerons dans ce qui suit le texte grec essentiellement suivant la meilleure rédaction de Petau, ce qui facilitera l'interprétation des passages que nous avons à considérer. En faisant la traduction j'ai tâché à rendre littéralement les expressions de l'original. À cette traduction est ajouté l'identification des étoiles y mentionnées. Confrontant mes résultats avec ceux de Delambre (I., p. 167-172) il est bien facile de s'apercevoir des différences essentielles dans l'interprétation des plus difficiles parties du texte original.

Χωρὶς δὲ τῆς ἐν ταῖς συνανατολαῖς καὶ δύσεσι θεωρίας, ἔυχρηστον εἰναι νομίζαι καὶ τὸ παρακολουθεῖν ἡμᾶς τίνες των ἀπλανῶν ἀστέρων ἀπέχουσι ἀπ' ἀλλήλων κατὰ τὸ ἑξῆς ὡριαῖα ἰσημερινὰ διαστήματα. τοῦτο γὰρ ἡμῖν ἔυχρηστόν ἐστιν πρός τε τὸ τὴν ὥραν τῆς νυκτὸς ἀκριβῶς συλλογίζεσθαι, καὶ πρὸς τὸ τοὺς ἐκλειπτικοὺς τής σελήνης χρόνους, καὶ ἕτερα πλείονα καταινοεῖν τῶν ἐν ἀστρολογίᾳ θεωρημάτων.

Outre cette doctrine sur les levers et les couchers simultanés des étoiles, je pense qu'il serait avantageux de faire suivre les étoiles fixes qui l'un après l'autre sont separées par des intervalles horaires équinoctiales. Elles seraient surtout utiles pour en conclure exactement l'heure de la nuit, et la durée d'une éclipse lunaire et pour faire savoir autres choses appartenantes aux théorèmes astronomiques.

O. 'Eπὶ *μὲν οὖν τοῦ διὰ τῶν τροπικῶν σημείων, καὶ διὰ τῶν πόλων γραφομένου κύκλου κεῖται ἀστὴρ ὁ ἐν ἄκρᾳ τῇ ὀυρᾷ τοῦ* Kυνὸς, *ἐν τῷ τὸ θερινὸν τροπικὸν σημεῖον ἔχοντι ἡμικυκλίῳ κείμενος.*

Ainsi sur le cercle décrit par les pôles et les points solstitiaux, se trouve l'étoile à l'extrémité de la queue du Chien, dans le demicercle qui contient le solstice d'été.

η Canis maj.

I. *'Aπὸ τούτου τοῦ ἀστέρος ἀπέχει ὡριαῖον διάστημα τοῦ τε "Yδρου ὁ ἐν τῇ ἐκφύσει τοῦ τραχήλου κείμενος· ἔγγιστα δὲ καὶ τῆς "*Aρκτου *ὁ ἐν τοῖς ἐμπροσθιοις γόνασι λαμπρός.*

De cette étoile à celle de l'Hydre, à la naissance du cou, il y a une heure. La brillante des genoux de devant de l'Ourse est à peu près à la même distance.

ζ Hydræ et θ Ursæ maj.

II. Tὸ *δὲ δέυτερον ὡριαῖον διάστημα ἀφορίζει τῶν ἐν τῷ* Λέοντι *ὁ προηγούμενος μικρῷ μεῖζον ἤ πῆχυν τοῦ ἐν τῇ καρδίᾳ λαμπροῦ μικρὸς ἀστερίσκος. τοῦ τε σφονδύλου προηγεῖται οὗτος ὁ ἀστερίσκος τοῦ διὰ τῶν πόλων κύκλου τὸ β' ὡριαῖον διάστημα ἀφορίζοντος.*

Le second intervalle horaire est marqué par la petite étoile qui précède la brillante du cœur du Lion, un peu plus que d'une coudée. Cette même étoile précède d'un sphondyle le cercle horaire qui marque le second intervalle horaire.*

ν Leonis.

III. Τὸ δὲ τρίτον ὡριαῖον διάστημα περὶ μέσον τὸν Λέοντα ἀφορίζει τοῦ Λέοντος ὁ νοτιώτερος τῶν β' τῶν ἐξ ἑκατέρου μέρους παρακειμένων τῷ ἐπὶ τῆς ὀσφύος λαμπρῷ.

Le troisième intervalle horaire est marqué au milieu du Lion, par l'australe des deux étoiles qui sont à côté de la brillante des reins.†

b Leonis.

IV. Τὸ δὲ τέταρτον ὡριαῖον διάστημα περὶ τὴν ἀρχὴν τῆς Παρθένου ἀφορίζει τοῦ ὑπὸ (ὑπὲρ) τὸν Κρατῆρα ὀρθογωνίου τριγώνου ὁ ἐπὶ τῆς ὀρθῆς γωνίας κείμενος ἀστήρ· ὁ δὲ ἐπὶ τῆς ὀσφύος τῆς μεγάλης Ἄρκτου λαμπρὸς, ἔλαττον (ἢ) κ' μέρος ὥρας ὑπολείπεται, τοῦ τὴν δ' ὥραν ἀφορίζοντος κύκλου.

Le quatrième intervalle horaire est marqué au commencement de la Vierge, par l'étoile qui est à l'angle droit du triangle situé au dessus de la Coupe. La brillante des reins de la grande Ourse suit un peu moins de $\frac{1}{20}$ d'heure le quatrième cercle horaire.

β Virginis et δ Ursæ maj.

V. Τὴν δὲ πέμπτην ὥραν ἀφορίζει περὶ μέσην τὴν Παρθένον ἀκριβῶς μὲν οὐδεὶς ἀστήρ τῷ δὲ ι' μέρει ὥρας πλέον ὑπολειπόμενος ὅ τε προτρυγήτὴρ, καὶ ὁ ἐπὶ τοῦ δεξιοῦ ὤμου τῆς Παρθένου κείμενος λαμπρὸς ἀστήρ.

Le cinquième intervalle horaire n'est marqué au milieu de la Vierge bien exactement par aucune étoile; mais et la Vendangeuse et la brillante étoile de l'épaule droite de la Vierge sont plus de $\frac{1}{10}$ d'heure en arrière.

ε et δ Virginis.

VI. Τὴν δὲ ἕκτην ὥραν ἀφορίζει ἐπὶ τοῦ διὰ τῶν ἰσημερινῶν σημείων κύκλου, ἔγγιστα μὲν τοῦ Κενταύρου ὁ επόμενος τῶν ἐν τῷ νοτιωτάτῳ μέρει τοῦ θύρσου λαμπρῶν, καὶ ὡς ἡμιπήχιον διεστηκότων· οἳ κεῖνται κατὰ μέσον πως τὸ στῆθος τοῦ Κενταύρου. τοῦ δὲ Βοώτου ὁ μεσος τῶν ἐν τῷ ἀριστερῷ ποδὶ, ὡς εἰκοστον μέρος ὡριαίου διαστήματας ὑπολείπεται τοῦ τὰς ϛ' ὥρας ἀφορίζοντος κύκλου.

Le sixième intervalle horaire est marqué sur le colure des équinoxes, par l'étoile du Centaure suivant des brillantes de la partie australe du Thyrse, et dont la distance est d'environ une demi-coudée. Ces étoiles sont vers le milieu de la poitrine du Centaure. La mitoyenne des étoiles du pied gauche du Bouvier est environ de $\frac{1}{20}$ d'heure en arrière du sixième cercle horaire.

φ Centauri et τ Bootis.

VII. Τῶν δὲ μεταξὺ τοῦ φθινοπωρινοῦ ἰσημερινοῦ σημείου, και τοῦ χειμερινοῦ τροπικοῦ ϛ' ὡριαίων διαστημάτων τὸ μὲν α' ὡριαῖον ἐπὶ τοῦ περὶ μέσας τὰς χηλὰς κύκλου ἀφορίζει, ὡς ἔγγιστα, τοῦ τε Βοώτου ὁ ἀριστερὸς ὦμος, καὶ ὁ ἐν ἄκρᾳ τῇ νοτιᾳ χηλῇ λαμπρὸς ἀστήρ. ὁ μὲν ὦμος ἀδιαφόρως πλεῖων ὑπολειπόμενος· ἡ δὲ χηλή, ὡς τριακοστὸν μέρος προηγουμένη τοῦ εἰρημένου διὰ τῶν πολων κύκλου.

Quant aux six intervalles horaires qui remplissent l'espace entre le colure de l'équinoxe d'automne et le colure du solstice d'hiver, le premier, passant par le milieu des Serres, est marqué à peu près par l'épaule gauche du Bouvier, et par la brillante étoile à l'extrémité de la Serre australe. L'épaule est un peu en arrière. Celle de la Serre précède environ de $\frac{1}{30}$ d'heure le susdit cercle.

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* πῆχυς = dzirâ = 2° 20′; σφονδύλος peut-être = schibr = $\frac{1}{4}$ πῆχυς = 45′±. Voir ma traduction d'Abd-al-Rahman al-Sûfi, p. 26 et 27.

† La brillante des reins est certainement δ. Les susdites étoiles sont Fl. 72 et b.

γ Bootis et α_1 Libræ.

VIII. Τὸ δὲ β' ὡριαῖον διάστημα ἀφορίζει περὶ τὴν ἀρχὴν τοῦ Σκορπίου, τοῦ τε Ὀφιούχου ὁ βορειότερος τῶν ἐν τῇ δεξιᾷ χειρὶ β' ἀστέρων λαμπρῶν, οἱ κεῖνται ἐν τῷ σώματι τοῦ Ὄφεως μετα δέξιὸν γόνυ τοῦ Ὀφιούχου. τοῦ δὲ Στεφάνου ὁ προηγούμενος τοῦ λαμπροῦ, ὡς λ' μέρος ὥρας ὑπολείπεται τοῦ διὰ τῶν πόλων κύκλου. ὁμοίως δὲ καὶ ὁ μέσος τῶν ἐν τῷ μετώπῳ τοῦ Σκορπίου γ' λαμπρῶν ἀστέρων.

Le second intervalle horaire est marqué au commencement du Scorpion, par la boréale des deux brillantes étoiles de la main droite d'Ophiuchus, et par celle qui se trouve sur le corps du Serpent après le genou droit. L'étoile qui précède la brillante de la Couronne, est environ de $\frac{1}{30}$ d'heure en arrière du cercle horaire. Pareillement encore la mitoyenne des trois brillantes étoiles du front du Scorpion.[*]

α et μ Serpentis, β Coronæ et δ Scorpii.

IX. Τὴν δὲ γ' ὥραν ἀφορίζει περὶ τὸ μέσον τοῦ Σκορπίου, τοῦ ἐν Γόνασιν ὁ ἐπὶ τοῦ δεξιοῦ ὤμου κείμενος ἀστήρ· καὶ ὁ ἐν μεσῃ τῇ δεξιᾷ κνήμῃ αὐτοῦ, ὡς λ' μέρος ὥρας πρὸς ἀνατολὰς παραλλάσσων.

Le troisième intervalle horaire est marqué au milieu du Scorpion, par l'étoile d'Hercule qui se trouve sur l'épaule droite. Celle du milieu de la jambe droite de la même constellation est plus à l'orient environ de $\frac{1}{30}$ d'heure.

β et φ Herculis.

X. Τὴν δὲ δ' ἀφορίζει περὶ τὴν ἀρχὴν τοῦ Τοξότου τοῦ τε ἐν Γόνασιν ὁ ἐν τῷ ἀριστερῷ μηρῷ λαμπρος, καὶ τῆς μικρᾶς Ἄρκτου οἱ λαμπρότατοι, καὶ ἡγούμενοι τῶν ἐν τῷ πλινθίῳ δ'. καὶ τοῦ Ὀφιούχου ἐν τῷ δεξιῷ ὤμῳ ὁ βορειότερος.

Le quatrième intervalle horaire est marqué au commencement du Sagittaire, par la brillante étoile de la cuisse gauche d'Hercule, et par les deux brillantes et précédentes des quatre étoiles du quadrilatère de la petite Ourse. Encore par la boréale de l'épaule droite d'Ophiuchus.

π Herculis, β et γ Ursæ min. et β Ophiuchi.

XI. Τήν δὲ ε' ὥραν ἀφορίζει περὶ μέσον τοῦ Τοξότου, τοῦ τε Τοξότου ὁ ἑπόμενος τῶν ἐν τῇ κεφαλῇ γ', ὡς λ' μέρος ὥρας πρὸς ἀνατολὰς παραλλασσων.

Le cinquième intervalle horaire est marqué au milieu du Sagittaire, par la suivante des trois de la tête du Sagittaire, qui est à l'orient environ de $\frac{1}{30}$ d'heure.

π Sagittarii.

XII. Τὴν δὲ ϛ' ὥραν ἀφορίζει ἐπὶ τοῦ διὰ τῶν τροπικῶν σημείων κύκλου, ὡς ἔγγιστα τῶν ἐν τῷ . . . . γ' λαμπρῶν ὁ βορειότερος, ὡς κ' μέρος μιᾶς ὥρας ὑπολειπόμενος τοῦ κύκλου.

Le sixième intervalle horaire est marqué sur le colure des solstices, à peu près

[*] Il faut bien remarquer qu'ici Hipparque a pris α et ε Serpentis pour la main droite d'Ophiuchus autrement que ne le fait Ptolémée qui a pris δ et ε Ophiuchi dans l'Almageste. Il suffit pour ce changement fait par Ptolémée à renvoyer au Livre VII. ch. 4. Il ne faut pas oublier que Ptoléméé a renversé l'image.

par la boréale des trois brillantes de . . . . , qui est en arrière du cercle horaire environ de $\frac{1}{20}$ d'heure.*

γ Aquilae.

XIII. Τῶν δὲ μεταξὺ τοῦ χειμερινοῦ τροπικοῦ σημείου, καὶ τοῦ ἐαρινοῦ ϛ' ὡριαίων διαστημάτων το μὲν α' ὡριαῖον διάστημα ἀφορίζει τοῦ Δελφῖνος ὁ βορειότερος τῶν ἡγονμένων ἐν τῷ ρόμβῳ· καὶ τοῦ 'Αιγοκέρωτος ὁ ἡγούμενος τῶν ἐν τῷ νώτῳ.

Quant aux six intervalles horaires qui remplissent l'espace entre le colure du solstice d'hiver et le colure de l'équinoxe du printemps, le premier est marqué par la boréale des précédentes du rhombe du Dauphin, et par la précédente du dos du Capricorne.

α Delphini et θ Capricorni.

XIV. Τὸ δὲ β' ὡριαῖον δίαστημα ἀφορίζει περὶ τὴν ἀρχὴν τοῦ 'Υδροχόου τῶν ἐν τῷ στόματι τοῦ "Ιππου λαμπρὸς ἀστὴρ· καὶ τοῦ Κηφέως ὁ νοτιώτερος τῶν προηγουμένων τοῦ δεξιοῦ ὤμου.

Le second intervalle horaire est marqué au commencement du Verseau, par la brillante étoile de la bouche du Cheval, et par l'australe des précédentes à l'épaule droite de Cephée.

ε Pegasi et η Cephei.

XV. Τὸ δὲ γ' ὡριαῖον διάστημα ἀφορίζει περὶ μέσον τοῦ 'Υδροχόου ὁ μέσος τῶν ἐν τῇ κεφαλῇ τοῦ Κηφέος γ' ἀστέρων ἐπ' ευθείας κειμένων· καὶ τοῦ "Ιππου τῶν ἐν τῷ τραχήλῳ β' ἀστέρων ὁ βορειότερος, ὡς τριακοστὸν μέρος ὥρας προηγούμενος τοῦ διὰ τῶν πόλων κύκλου.

Le troisième intervalle horaire est marqué au milieu du Verseau, par la mitoyenne des trois étoiles qui se trouvent sur la tête de Cephée. Encore par la boréale des deux étoiles du cou du Cheval, qui précède environ de $\frac{1}{30}$ d'heure le cercle horaire.

ζ Cephei et ξ Pegasi.

XVI. Τὸ δὲ δ' ὡριαῖον διάστημα ἀφορίζει περὶ τὴν ἀρχὴν τῶν 'Ιχθύων τῆς 'Ανδρομέδας τῶν ἐν τῇ δεξιᾷ χειρὶ ἀστέρων ὁ νοτιώτατος, ὡς κ' μέρος ὥρας ὑπολειπόμενος τοῦ διὰ τῶν πόλων κύκλου.

Le quatrième intervalle horaire est marqué au commencement des Poissons, par l'australe des (trois) étoiles de la main droite d'Andromède, qui est environ de $\frac{1}{20}$ d'heure en arrière du cercle horaire.

ι Andromedæ.

XVII. Τὸ δὲ ε' ὡριαῖον διάστημα περὶ μέσους τοὺς 'Ιχθύας ἀφορίζει τῆς Κασσιεπείας ὁ ἐν μέσῳ τῷ σωματι, καὶ τρίτος, ἀπὸ τῆς κεφαλῆς ἀριθμούμενος.

Le cinquième intervalle horaire est marqué au milieu des Poissons, par l'étoile du milieu du corps de Cassiépée, qui est la troisième en partant de la tête.

η Cassiopeiæ.

XVIII. Τὸ δὲ ϛ' ὡριαῖον διὰστημα ἀφορίζει ἀπ' ἀυτοῦ ἔγγιστα τοῦ διὰ τῶν ἰσημερινῶν σημείων, καὶ τῶν πόλων γραφομένου κύκλου, ὁ ἐπὶ τῆς Κορυφῆς κείμενος τοῦ ὑπὲρ τὸν Κριὸν κειμένου. ὁ δὲ ἡγούμενος τῶν ἐν τῇ κεφαλῇ τοῦ Κριοῦ γ' λαμπρῶν, ὡς ἔικοστὸν μέρος (ὥρας) ὑπολείπεται καὶ τοῦ κύκλου.

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* J'ai adopté la conjecture de Delambre, I., p. 170.

Le sixième intervalle horaire est marqué près du colure des équinoxes, par l'étoile au sommet (κορυφη du Triangle) au dessus du Bélier. La précédente des trois brillantes de la tête du Bélier est environ de $\frac{1}{20}$ d'heure en arrière du cercle.

α Trianguli et γ Arietis.

XIX. *Τῶν δὲ μεταξὺ τοῦ ἰσημερινοῦ, καὶ τοῦ θερινοῦ σημείου ἕξ ὡριαίων διάστηματων, τὸ μὲν α' διάστημα ἀφορίζει ὁ λαμπρότατος τῶν ἐν τῷ Γοργονίῳ, ὃ ἔχει ὁ Περσεὺς ἐν τῇ ἀριστερᾷ χειρί.*

Quant aux six intervalles horaires qui remplissent l'espace entre le colure de l'équinoxe du printemps et le colure du solstice d'été, le premier est marqué par l'étoile brillante située dans la tête de Méduse que tient Persée à la main gauche.

β Persei.

XX. *Τὸ δὲ β' διάστημα ὡριαῖον ἀφορίζει περὶ τὴν ἀρχὴν τοῦ Ταύρου τοῦ Περσέως τῶν περὶ τὸ δεξιὸν γόνυ ε' ἀστέρων ὁ ἑπόμενος τῶν ἐπ' εὐθείας τριῶν.*

Le second intervalle horaire est marqué au commencement du Taureau, par l'étoile suivante des trois placées en ligne droite et appartenant aux cinq étoiles situées dans le genou droit de Persée.

d Persei.

XXI. *Τό δὲ γ' ὡριαῖον διάστημα ἀφορίζει περὶ μέσον τὸν Ταῦρον τῶν ἐν τῇ δορᾷ, ἣν ἔχει ὁ 'Ωρίων ἐν τῇ ἀριστερᾷ χειρὶ, ὁ δ', καὶ ὁ ζ'· καὶ τοῦ Ταύρου ὁ ἐν μέσοις τοῖς κέρασιν ἐκφανὴς, ἰσόπλεωρον ἔγγιστα τρίγωνον πωιῶν μετὰ τῶν ἐν ἄκροις τοῖς κέρασι λαμπρῶν.*

Le troisième intervalle horaire est marqué au milieu du Taureau, par la quatrième et la septième étoile de la peau que tient Orion dans la main gauche. Encore par l'étoile brillante au milieu des cornes du Taureau, faisant un triangle presqu' équilatéral avec les deux brillantes des extrémités des cornes.

π_4 et π_3 Orionis, et ι Tauri.

XXII. *Τὸ δὲ δ' ὡριαῖον διάστημα ἀφορίζει περὶ τὴν ἀρχὴν τῶν Διδύμων, τοῦ Ταύρου τῶν ἐπ' ἐνθειας ἄκρῳ τῷ δεξιῷ κέρατι πρὸς ἀνατολὰς κειμένων β' μικρῶν, καὶ ἐκφανῶν ὄντων ἀστερίσκων ὁ ἑπόμενος ἀυτῶν. ἐισὶν δὲ οὗτοι καὶ ἐν τῷ κολλορόβῳ τοῦ 'Ωρίωνος ἐπὶ τοῦ βορειοτέρου πέρατος. ἔγγιστα δὲ τὴν δ' ἀφορίζει καὶ τοῦ Λαγωοῦ ὁ νοτιώτερος τῶν ἐν μέσῳ τῷ σώματι β' λαμπρῶν.*

Le quatrième intervalle horaire est marqué au commencement des Gémeaux, par la suivante des deux petites bien visibles étoiles qui à l'orient sont placées en ligne droite avec l'extrémité de la corne droite du Taureau. Ces mêmes étoiles sont situées sur l'extrémité boréale de la massue d'Orion. Le quatrième intervalle est encore marqué à peu près par l'australe des deux brillantes étoiles situées dans le milieu du corps du Lièvre.

χ_4 Orionis et α Leporis.

XXIII. *Τὸ δὲ ε' ὡριαῖον διάστημα ἀφυρίζει περὶ μέσους τοὺς Διδύμους τῶν Διδύμων ὁ μέσος τῶν ἐν τοῖς γόνασι γ' λαμπρῶν, ὡς λ' μέρος ὥρας προηγούμενος τοῦ διὰ τῶν πόλων κύκλου· καὶ τοῦ Κυνὸς ὁ ἐν τοῖς ὀπισθίοις ποσὶ λαμπρός.*

Le cinquième intervalle horaire est marqué au milieu des Gémeaux, par la mitoyenne des trois brillantes étoiles des genoux des Gémeaux, qui précède le cercle horaire environ de $\frac{1}{30}$ d'heure. Encore par la brillante des pieds de derrière du Chien.

ζ Geminorum et ζ Canis maj.

Afin de nous préparer à apprécier les observations d'Hipparque, il faut remettre sous nos yeux l'état du ciel tel qu'il était à l'époque ancienne où on les représente comme ayant été faites, c'est-à-dire environ au milieu du deuxième siècle avant l'ère chrétienne. J'ai donc calculé par des formules exactes, pour quelques siècles avant et après cette même date, les coordonnées équatoriales de toutes les étoiles dont Hipparque avait parlé, et j'en ai formé le tableau que j'ai inséré à la suite. Il nous fournira tous les reseignements numériques dont nous aurons besoin pour faire la comparaison avec les indications contenues dans le texte d'Hipparque. Ces évaluations peuvent être influencées par de petites erreurs s'élevant, tout au plus, à quelques minutes de degré, par suite des incertitudes que présentent les données des formules quand on les applique à des temps si reculés. D'ailleurs j'ai tenu compte des mouvements propres des étoiles considérés d'après les données dont Mädler nous a fourni.

Considérons, pour faire le calcul dont il s'agit, le triangle sphérique NUV formé par l'écliptique fixe UV de 1850 et les deux positions NV et NU de l'équateur pour les deux époques 1850 et 1850 + t. Appelons $180^\circ-\omega$, ω' les angles NVU, NUV, et ψ le côté adjacent UV, dit précession lunisolaire. Ces trois quantités ω, ω', ψ sont connues par les formules de la précession.

Posons encore θ le troisième angle du triangle et $90^\circ-\zeta$, $90^\circ+\zeta'$ les deux côtés NV, NU qui le comprennent ; les formules—

$$\begin{aligned}
\sin\tfrac{1}{2}(\zeta'+\zeta)\cos\tfrac{1}{2}\theta &= \sin\tfrac{1}{2}\psi\cos\tfrac{1}{2}(\omega'+\omega)\\
\cos\tfrac{1}{2}(\zeta'-\zeta)\sin\tfrac{1}{2}\theta &= \sin\tfrac{1}{2}\psi\sin\tfrac{1}{2}(\omega'+\omega)\\
\cos\tfrac{1}{2}(\zeta'+\zeta)\cos\tfrac{1}{2}\theta &= \cos\tfrac{1}{2}\psi\cos\tfrac{1}{2}(\omega'-\omega)\\
\sin\tfrac{1}{2}(\zeta'-\zeta)\sin\tfrac{1}{2}\theta &= \cos\tfrac{1}{2}\psi\sin\tfrac{1}{2}(\omega'-\omega)
\end{aligned}$$

feront connaître ζ, ζ' et θ, quantités qui ne dépendent pas de l'ascension droite et de la déclinaison.

Soient α et δ l'ascension dr. et la déclinaison d'une étoile à l'époque 1850 ; α' et δ' les valeurs que prennent ces coordonnées à l'époque 1850+t. Désignons de plus V′ l'intersection entre l'écliptique et l'équateur à l'époque 1850+t, et appelons λ' l'arc UV′, on a—

$$\begin{aligned}
\cos\delta'\sin(\alpha'+\lambda'-\zeta') &= \cos\delta\sin(\alpha+\zeta)\\
\cos\delta'\cos(\alpha'+\lambda'-\zeta') &= \cos\delta\cos(\alpha+\zeta)\cos\theta-\sin\delta\sin\theta\\
\sin\delta' &= \cos\delta\cos(\alpha+\zeta)\sin\theta+\sin\delta\cos\theta,
\end{aligned}$$

ou, en posant $\lambda'-\zeta'=A'$—

$$\left.\begin{aligned}
\cos\delta'\sin(\alpha'+A') &= \cos\delta\sin(\alpha+\zeta)\\
\cos\delta'\cos(\alpha'+A') &= \cos\delta\cos(\alpha+\zeta)\cos\theta-\sin\delta\sin\theta\\
\sin\delta' &= \cos\delta\cos(\alpha+\zeta)\sin\theta+\sin\delta\cos\theta
\end{aligned}\right\}\;.\;:\;.\;(\mathrm{A}).$$

Désignons par Q' et q les valeurs de α' et δ qui correspondent à $\delta'=0$ dans les équations précédentes, on aura—

$$\left.\begin{aligned}\sin(Q'+A')&=\cos q\sin(\alpha+\zeta)\\ \cos(Q'+A')&=\cos q\cos(\alpha+\zeta)\cos\theta-\sin q\sin\theta\\ 0&=\cos q\cos(\alpha+\zeta)\sin\theta+\sin q\cos\theta\end{aligned}\right\}\;\ldots\;(\mathrm{B}).$$

ou—

$$\left.\begin{aligned}\sin(Q'+A')&=\cos q\sin(\alpha+\zeta)\\ \cos(Q'+A')\cos\theta&=\cos q\cos(\alpha+\zeta)\\ \cos(Q'+A')\sin\theta&=-\sin q\end{aligned}\right\}\;\ldots\ldots\ldots\;(\mathrm{C}).$$

d'où il résulte—

$$\left.\begin{aligned}\operatorname{tang}(Q'+A')&=\operatorname{tang}(\alpha+\zeta)\cos\theta\\ \operatorname{tang}q&=-\cos(\alpha+\zeta)\operatorname{tang}\theta\end{aligned}\right\}\;\ldots\ldots\ldots\;(\mathrm{C}').$$

On voit facilement que la troisième des équations (B) est satisfaite en posant—

et—

$$\left.\begin{aligned}\cos\theta&=\cos\gamma\cos q\\ \sin\theta\cos(\alpha+\zeta)&=-\cos\gamma\sin q\end{aligned}\right\}\;\ldots\ldots\ldots\;(\mathrm{D}).$$

qui donnent lieu à—

$$\sin\gamma=\sin\theta\sin(\alpha+\zeta)\;\ldots\ldots\ldots\ldots\;(\mathrm{D}').$$

En posant dans les deux premières équations (A) $\alpha'+A'=\alpha'-Q'+Q'+A'$, on obtient—

$$\cos\delta'\sin(\alpha'-Q')\cos(Q'+A')+\cos\delta'\cos(\alpha'-Q')\sin(Q'+A')=\cos\delta\sin(\alpha+\zeta).$$
$$\cos\delta'\cos(\alpha'-Q')\cos(Q'+A')-\cos\delta'\sin(\alpha'-Q')\sin(Q'+A')=\cos\delta\cos(\alpha+\zeta)\cos\theta-\sin\delta\sin\theta.$$

En retranchant de la première de ces équations, multipliée par $\cos(Q'+A')$, la seconde multipliée par $\sin(Q'+A')$; puis en ajoutant à la première multipliée par $\sin(Q'+A')$, la seconde multipliée par $\cos(Q'+A')$, on obtient—

$$\cos\delta'\sin(\alpha'-Q')=\cos\delta\sin(\alpha+\zeta)\cos(Q'+A')-\cos\delta\cos(\alpha+\zeta)\sin(Q'+A')\cos\theta+\sin\delta\sin(Q'+A')\sin\theta.$$
$$\cos\delta'\cos(\alpha'-Q')=\cos\delta\sin(\alpha+\zeta)\sin(Q'+A')+\cos\delta\cos(\alpha+\zeta)\cos(Q'+A')\cos\theta-\sin\delta\cos(Q'+A')\sin\theta.$$

ou en y substituant les expressions pour $\sin(Q'+A')$ et $\cos(Q'+A')$ des équations (B)—

$$\cos\delta'\sin(\alpha'-Q')=\sin(\alpha+\zeta)\sin\theta\sin(\delta-q).$$
$$\cos\delta'\cos(\alpha'-Q')=\cos(\delta-q).$$

En employant les expressions (D) et (D′) à la première de ces équations et à la troisième des équations (A), on obtient finalement—

$$\left.\begin{aligned}\cos\delta'\sin(\alpha'-Q')&=\sin\gamma\sin(\delta-q)\\ \cos\delta'\cos(\alpha'-Q')&=\cos(\delta-q)\\ \sin\delta'&=\cos\gamma\sin(\delta-q)\end{aligned}\right\}\;\ldots\ldots\ldots\;(\mathrm{A}')$$

en calculant Q', q et γ par les formules (C′) et (D′).

Pour faire compte de l'effet du mouvement propre des étoiles, nous avons employé les formules suivantes—

$$\Delta\alpha'=\cos(\alpha'-Q')\cos\gamma\sec\delta'\cos\delta\cdot\Delta\alpha+\sin\gamma\sec^2\delta'\cdot\Delta\delta,$$
$$\Delta\delta'=-\sin\gamma\sec\delta'\cdot\cos\delta\cdot\Delta\alpha+\cos(\alpha'-Q')\cos\gamma\cdot\Delta\delta,$$

qui s'obtiennent de cette manière.

Différentions la troisième des équations (A′) nous obtiendrons—

$$\cos\delta'd\delta'=-\sin\gamma\sin(\delta-q)d\gamma-\cos\gamma\cos(\delta-q)dq+\cos\gamma\cos(\delta-q)d\delta.$$

Si l'on remplace d_γ et dq par les expressions—

$$d\gamma=-\sin q\,d\alpha\quad,\quad dq=\cos q\operatorname{tang}\gamma\,d\alpha,$$

tirées des équations (D) et (D′) en regardant θ comme constante, on a d'après quelques faciles transformations—

$$\cos\delta' d\delta' = -\sin\gamma\cos\delta d\alpha + \cos\gamma\cos(\delta-q)d\delta,$$

ou en employant la deuxième des équations (A′)—

$$d\delta' = -\sin\gamma\sec\delta'\cos\delta\, d\alpha + \cos(\alpha'-Q')\cos\gamma\, d\delta.$$

Puis en différentiant la seconde des équations (A′) en y faisant tout varier, nous obtiendrons—

$$\sin\delta'\cos(\alpha'-Q')d\delta' + \cos\delta'\sin(\alpha'-Q')d(\alpha'-Q') = \sin(\delta-q)d(\delta-q),$$

ou en remarquant que—

$$\sin(\delta-q) = \frac{\sin\delta'}{\cos\gamma} \text{ et } \cos\delta'\sin(\alpha'-Q') = \sin\gamma\sin(\delta-q) = \text{tang}\,\gamma\sin\delta',$$

$$d\alpha' = \frac{d\delta}{\sin\gamma} - \frac{dq}{\sin\gamma} + dQ' - \cot\gamma\cos(\alpha'-Q')d\delta'.$$

On simplifie beaucoup cette équation, par la remarque que d'après les formules (C), (D) et (D′) on a $dq = \sin\gamma\, dQ'$, ainsi—

$$d\alpha' = \frac{d\delta}{\sin\gamma} - \cot\gamma\cos(\alpha'-Q')d\delta',$$

ou, en y substituant la valeur susdite de $d\delta'$—

$$d\alpha' = \cos(\alpha'-Q')\cos\gamma\sec\delta'\cos\delta\, d\alpha + \frac{1-\cos^2(\alpha'-Q')\cos^2\gamma}{\sin\gamma}\, d\delta.$$

Finalement on obtient, en remarquant que d'après les formules (A′),

$$1-\cos^2(\alpha'-Q')\cos^2\gamma = 1 - \frac{\cos^2\gamma - \sin^2\delta'}{\cos^2\delta'} = \frac{\sin^2\gamma}{\cos^2\delta'},$$

$$d\alpha' = \cos(\alpha'-Q')\cos\gamma\sec\delta'\cos\delta\, d\alpha + \sin\gamma\sec^2\delta' d\delta.$$

Reprenons l'ensemble des formules relatives à la détermination de la position d'une étoile à l'époque 1850+*t*. Les formules—

$$\begin{aligned} \text{tang}(Q'+A') &= \text{tang}(\alpha+\zeta)\cos\theta \\ \sin\gamma &= \sin(\alpha+\zeta)\sin\theta \\ -\text{tang}\, q &= \cos(\alpha+\zeta)\text{tang}\,\theta, \end{aligned}$$

donnent Q′, γ et q. Puis les coordonnées α' et δ' se déterminent par—

$$\begin{aligned} \sin\delta' &= \cos\gamma\sin(\delta-q) \\ \cos\delta'\sin(\alpha'-Q') &= \sin\gamma\sin(\delta-q) \\ \cos\delta'\cos(\alpha'-Q') &= \cos(\delta-q), \end{aligned}$$

et finalement $\Delta\alpha'$ et $\Delta\delta'$ par—

$$\begin{aligned} \Delta\alpha' &= \cos(\alpha'-Q')\cos\gamma\sec\delta'\cos\delta\Delta\alpha + \sin\gamma\sec^2\delta'\Delta\delta \\ \Delta\delta' &= -\sin\gamma\sec\delta'\cos\delta\Delta\alpha + \cos(\alpha'-Q')\cos\gamma\Delta\delta, \end{aligned}$$

où $\Delta\alpha = \mu\cdot\frac{t}{100}$ et $\Delta\delta = \nu\cdot\frac{t}{100}$, μ et ν étant les mouvements propres séculaires en ascension dr. et en décl.

Il nous reste maintenant à déterminer les valeurs numériques des quantités ζ, A′ et θ.

Suivant Leverrier nous avons adopté pour l'époque 1850+*t*.

$$\begin{aligned} \psi &= 50''\cdot37040\,t - 0''\cdot0001088 \\ \lambda &= 0''\cdot14674\,t - 0''\cdot0002417t \\ \omega &= 23°\ 27'\ 31''\cdot8 + 0''\cdot00000719\,t^2 \\ \omega' &= 23°\ 27'\ 31''\cdot8 - 0''\cdot47594\,t - 0''\cdot00000149\,t^2. \end{aligned}$$

D'après les formules susdites nous avons calculé pour le commencement de tous les siècles entre —300 et +200 inclusive les valeurs de ζ, A′ et θ et les insérées dans la table suivante.

1850+*t*.	ζ.	Diff.	A′.	Diff.	θ.	Diff.
—300	13° 52′ 9″·1	—39′ 8″·5	13° 33′ 25″·5	—37′ 26″·0	—11° 54′ 56″·8	+32′ 47″·9
—200	13 13 0·6	—39 5·2	12 55 59·5	—37 27·6	—11 22 8·9	+32 52·1
—100	12 33 55·4	—39 2·1	12 18 31·9	—37 29·4	—10 49 16·8	+32 56·3
0	11 54 53·3	—38 59·0	11 41 2·5	—37 31·3	—10 16 20·5	+33 0·1
+100	11 15 54·3	—38 56·0	11 3 31·2	—37 33·2	— 9 43 20·4	+33 3·7
+200	10 36 58·3		10 25 58·0		— 9 10 16·7	

Nous avons aussi calculé les valeurs de ζ, A′ et θ en adoptant les données d'après Hansen (Astron. Nachr. Nr. 826, p. 153, et Tafeln der Egeria, p. 447):—

$$\psi = 50''\cdot35841\,t - 0''\cdot00010674\,t^2$$
$$\lambda = 0''\cdot13544\,t - 0''\cdot00023859\,t^2$$
$$\omega = 23^\circ\ 27'\ 31''\cdot4 + 0''\cdot000007046\,t^2$$
$$\omega' = 23^\circ\ 27'\ 31''\cdot4 - 0''\cdot467839\,t - 0''\cdot000001405\,t^2,$$

pour l'époque 1850+*t*.

Voici la table même des constantes.

1850+*t*.	ζ.	Diff.	A′.	Diff.	θ.	Diff.
—300	13° 51′ 55″·8	—39′ 7″·6	13° 33′ 44″·7	—37′ 27″·2	—11° 54′ 42″·8	+32′ 47″·0
—200	13 12 48·2	—39 4·6	12 56 17·5	—37 29·0	—11 21 55·8	+32 51·7
—100	12 33 43·6	—39 1·2	12 18 48·5	—37 30·7	—10 49 4·1	+32 55·1
0	11 54 42·4	—38 58·2	11 41 17 8	—37 32·3	—10 16 9·0	+32 59·4
+100	11 15 44·2	—38 55·4	11 3 45·5	—37 34·4	— 9 43 9·6	+33 3·0
+200	10 36 48·8		10 26 11·1		— 9 10 6·6	

On peut facilement avec ces tables refaire et vérifier mes calculs qui suivent.

Nous allons donc donner l'ensemble des coordonnées pour les étoiles dont Hipparque a fait mention telles que nous les avons obtenues en partant des valeurs de ζ, A′ et θ suivant Leverrier.

TABLES–EPHÉMÉRIDES

pour les 44 étoiles dont Hipparque a fait mention.

O. η **Canis majoris.**

	α'	$\Delta\alpha'$	δ'	$\Delta\delta'$
—300	88° 25′ 34″·4	+0′ 48″·5	—27° 10′ 33″·0	—0′ 27″·4
—200	89 24 2·1	46·0	9 44·0	26·5
—100	90 22 33·1	43·4	9 31·0	25·6
0	91 21 7·6	40·9	9 52·6	24·7
+100	92 19 45·3	38·3	10 50·0	23·8

I. *a*. ζ **Hydræ.**

	α'	$\Delta\alpha'$	δ'	$\Delta\delta'$
—300	102° 42′ 29″·6	+2′ 23″·0	+11° 57′ 47″·2	+0′ 41″·0
—200	104 5 11·4	2 16·6	50 8·4	38·1
—100	105 27 48·1	2 10·2	41 41·7	35·3
0	106 50 20·0	2 3·8	32 27·3	52·4
+100	108 12 46·0	1 57·4	22 25·9	29·6

I. *b.* θ Ursæ majoris.

	α′	Δα′	δ′	Δδ′
−300	98° 9′ 39″·1	+50′ 19″·0	+58° 15′ 3″·1	+30′ 45″·7
−200	100 19 11·1	48 52·0	9 49·0	28 51·6
−100	102 28 10·4	47 16·9	3 18·2	27 0·1
0	104 36 30·8	45 33·5	57 55 33·2	25 11·2
+100	106 44 5·3	43 41·9	46 34·5	23 24·9

II. ν Leonis majoris.

	α′	Δα′	δ′	Δδ′
−300	117 22 36·4	+0 35·5	+21 11 45·9	+0 5·4
−200	118 49 52·4	33·8	20 56 1·2	4·9
−100	120 16 51·4	32·1	39 31·6	4·4
0	121 43 33·6	30·4	22 17·4	3·9
+100	123 9 58·2	28·8	4 19·4	3·4

III. *b* Leonis.

	α′	Δα′	δ′	Δδ′
−300	133 4 8·7	−0 35·9	+31 7 16·0	−1 19·7
−200	134 34 34·0	34·7	30 44 2·0	15·8
−100	136 4 26·4	33·5	30 20 10·4	11·9
0	137 33 45·3	32·3	29 55 41·3	8·0
+100	139 2 30·7	31·0	29 30 37·0	4·0

IV. *a.* β Virginis.

	α′	Δα′	δ′	Δδ′
−300	147 44 41·2	−13 51·2	+13 55 7·4	+4 44·6
−200	149 4 48·4	13 10·1	13 26 28·9	34·7
−100	150 24 38·2	12 29·0	12 57 25·8	24·8
0	151 44 12·7	11 47·9	12 28 0·2	14·9
+100	153 3 31·8	11 6·7	11 58 12·3	4·9

IV. *b.* δ Ursæ majoris.

	α′	Δα′	δ′	Δδ′
−300	148 19 19·0	−15 14·7	+69 23 46·5	+0 14·3
−200	150 20 40·1	14 26·9	68 54 49·3	17·6
−100	152 18 16·4	13 32·3	68 25 18·5	20·5
0	154 12 19·5	12 30·9	67 54 18·9	23·0
+100	156 3 0·7	11 22·8	67 24 46·1	25·0

V. *a.* ε Virginis.

	α′	Δα′	δ′	Δδ′
−300	166 14 17·8	+9 57·4	+23 40 56·3	−0 51·2
−200	167 33 26·6	9 27·4	23 8 7·2	50·0
−100	168 52 14·7	8 57·5	22 35 8·8	48·8
0	170 10 40·4	8 27·8	22 2 1·7	47·1
+100	171 28 46·8	7 58·3	21 28 47·5	45·4

V. *b.* δ Virginis.

	α′	Δα′	δ′	Δδ′
−300	164 30 55·6	+17 7·5	+16 7 22·6	+2 46·0
−200	165 49 11·0	16 17·9	15 34 48·6	36·4
−100	167 7 12·0	15 28·3	15 2 4·0	26·8
0	168 24 59·1	14 38·7	14 29 9·6	17·2
+100	169 42 32·9	13 49·2	13 56 6·5	7·7

VI. *a.* φ Centauri.

	α′	Δα′	δ′	Δδ′
−300	178 1 4·8	+1 49·3	−29 43 46·0	+6 43·9
−200	179 16 17·4	44·7	30 17 29·6	6 25·1
−100	180 31 58·7	40·1	30 51 12·6	6 6·3
0	181 48 10·3	35·5	31 24 54·6	5 47·5
+100	183 4 53·6	31·0	31 58 34·0	5 28·7

VI. *b.* τ Bootis.

	α′	Δα′	δ′	Δδ′
−300	178 41 23·3	+18 11·8	+29 52 36·0	−2 12·0
−200	179 57 29·0	17 16·2	29 18 52·3	5·7
−100	181 13 11·9	16 20·6	28 45 9·0	1 59·4
0	182 28 33·0	15 25·0	28 11 27·7	53·1
+100	183 43 34·1	14 29·5	27 37 49·3	46·9

VII. *a.* γ Bootis.

	α′	Δα′	δ′	Δδ′
−300	194° 3′ 7″·0	+1′ 31″·2	+49° 46′ 18″·7	−5′ 12″·5
−200	195 9 7·5	27·6	49 13 36·8	4 57·8
−100	196 14 38·6	24·1	48 41 7·2	43·1
0	197 19 41·5	20·7	48 8 48·0	28·5
+100	198 24 18·3	17·3	47 36 42·0	13·9

VII. *b.* $α_1$ Libræ.

	α′	Δα′	δ′	Δδ′
−300	192 14 17·2	+3 23·7	−4 40 36·9	+2 46·7
−200	193 30 41·2	14·0	5 13 32·4	39·4
−100	194 47 17·3	4·3	5 46 16·3	32·1
0	196 4 5·1	2 54·6	6 18 48·0	24·8
+100	197 21 6·0	45·0	6 51 6·3	17·5

VIII. *a.* α Serpentis.

	α′	Δα′	δ′	Δδ′
−300	208 22 49·6	−6 25·7	+15 53 19·8	−1 2·9
−200	209 34 3·6	6·7	15 23 44·0	1 1·6
−100	210 45 19·8	5 47·7	14 54 29·9	1 0·2
0	211 56 38·3	28·7	14 25 38·6	0 58·9
+100	213 7 59·6	9·8	13 57 10·4	0 57·5

VIII. *b.* μ Serpentis.

	α′	Δα′	δ′	Δδ′
−300	208 13 47·4	+2 17·2	+5 56 45·6	+0 46·2
−200	209 27 57·0	2 10·6	5 27 7·7	44·6
−100	210 42 14·2	2 4·0	4 57 52·2	43·0
0	211 56 39·8	1 57·4	4 29 0·4	41·4
+100	213 11 14·2	1 50·7	4 0 32·8	39·7

VIII. *c.* β Coronæ.

	α′	Δα′	δ′	Δδ′
−300	208 7 33·4	+5 11·1	+38 53 38·1	−3 22·0
−200	209 10 30·9	4 56·0	38 23 57·0	11·3
−100	210 13 18·8	41·1	37 54 34·7	0·6
0	211 15 58·3	26·3	37 25 32·8	2 50·0
+100	212 28 30·3	11·6	36 56 50·5	2 39·5

VIII. *d.* δ Scorpii.

	α′	Δα′	δ′	Δδ′
−300	207 50 16·3	−0 8·4	−13 24 57·4	+1 6·4
−200	209 9 54·7	8·4	13 54 41·3	3·3
−100	210 29 55·9	8·3	14 24 0·9	0·2
0	211 50 19·2	8·2	14 52 55·6	0 57·1
+100	213 11 5·6	8·1	15 21 24·3	54·0

IX. *a.* β Herculis.

	α′	Δα′	δ′	Δδ′
−300	223 6 49·4	+3 9·3	+28 47 0·5	−1 8·6
−200	224 9 58·7	0·4	28 22 28·6	4·3
−100	225 13 9·3	2 51·5	27 58 23·8	0·0
0	226 16 21·5	42·6	27 34 46·5	0 55·7
+100	227 19 35·7	33·7	27 11 37·3	51·5

IX. *b.* φ Herculis.

	α′	Δα′	δ′	Δδ′
−300	224 31 16·5	+5 19·9	+52 36 57·7	−2 16·7
−200	225 16 16·1	4·8	52 12 56·0	8·5
−100	226 1 21·2	4 49·6	51 49 15·0	2 0·3
0	226 46 31·0	34·5	51 25 54·0	1 52·1
+100	227 31 46·4	19·3	51 2 54·5	1 43·9

X. *a.* π Herculis.

	α′	Δα′	δ′	Δδ′
−300	239 5 44·0	−0 12·1	+41 26 59·5	−0 28·8
−200	239 56 2·2	11·1	41 9 43·0	27·5
−100	240 46 25·8	10·2	40 52 54·0	26·2
0	241 36 54·2	9·2	40 36 32·5	24·9
+100	242 27 28·9	8·3	40 20 37·5	23·7

X. *b.* β Ursæ min.

	α′	Δα′	δ′	Δδ′
−300	244° 59′ 0″·7	+13′ 9″·6	+82° 32′ 59″·0	+0′ 11″·3
−200	242 27 54·3	12 0·9	82 17 52·0	17·3
−100	240 9 24·1	10 54·1	82 1 32·0	22·2
0	238 3 2·7	9 48·6	81 44 4·0	26·2
+100	236 8 18·3	8 44·2	81 25 37·0	29·2

X. *c.* γ Ursæ min.

−300	243 20 8·0	−9 6·8	+79 22 8·5	+0 55·0
−200	241 58 38·0	8 41·1	79 6 29·0	48·1
−100	240 43 0·8	8 14·1	78 50 9·5	41·5
0	239 33 0·7	7 45·8	78 33 17·0	35·3
+100	238 28 26·2	7 16·2	78 15 48·0	29·7

X. *d.* β Ophiuchi.

−300	237 53 46·9	−0 1·0	+8 33 57·4	−5 59·4
−200	239 5 18·5	+0 1·6	8 16 10·7	42·7
−100	240 16 59·1	4·3	7 59 1·5	25·9
0	241 28 47·9	6·9	7 42 29·9	9·2
+100	242 40 45·7	9·6	7 26 36·6	4 52·4

XI. π Sagittarii.

−300	253 9 21·1	+0 12·7	−21 3 13·4	+1 5·2
−200	254 37 37·9	11·6	12 45·0	2·1
−100	256 6 8·5	10·5	21 25·0	0 59·0
0	257 34 52·2	9·4	29 13·9	55·9
+100	259 3 48·0	8·2	36 10·4	52·9

XII. γ Aquilæ.

−300	269 12 53·5	−1 57·9	+7 47 49·2	+0 20·1
−200	270 24 2·6	52·4	47 32·1	18·2
−100	271 35 14·7	46·9	47 57·7	16·3
0	272 46 29·7	41·4	49 6·0	14·4
+100	273 57 46·8	35·9	50 57·1	12·6

XIII. *a.* α Delphini.

−300	283 11 45·0	−3 33·4	+10 14 6·5	+0 16·8
−200	284 21 33·4	23·6	21 58·4	14·4
−100	285 31 21·9	13·8	30 30·7	12·0
0	286 41 10·3	4·0	39 43·5	9·6
+100	287 50 58·6	2 54·3	49 36·1	7·1

XIII. *b.* θ Capricorni.

−300	282 59 4·3	−3 40·8	−23 32 6·2	+2 27·6
−200	284 29 5·5	31·8	24 15·6	18·6
−100	285 58 57·3	22·7	15 33·2	9·9
0	287 28 39·9	13·5	5 59·3	1·5
+100	288 58 11·1	4·1	22 55 34·4	1 53·1

XIV. *a.* ε Pegasi.

−300	297 37 2·7	−1 0·3	+1 23 40·3	−0 14·3
−200	298 52 1·5	0 57·3	39 29·0	14·1
−100	300 6 54·3	54·3	55 56·6	13·9
0	301 21 43·4	51·5	2 13 2·8	13·6
+100	302 36 27·6	48·7	30 47·0	13·3

XIV. *b.* η Cephei.

−300	298 50 46·0	−23 12·5	+54 25 10·5	−26 25·9
−200	299 25 0·8	21 37·5	54 41 27·5	25 23·0
−100	299 59 10·1	20 5·1	54 58 1·0	24 19·0
0	300 33 11·5	18 35·3	55 14 53·0	23 14·0
+100	301 7 5·5	17 8·2	55 32 2·5	22 8·1

XV. *a.* ζ Cephei.

	α′	Δα′	δ′	Δδ′
−300	313° 35′ 46″·8	−0′ 58″·9	+47° 58′ 58″·0	+0′ 26″·0
−200	314 24 18·1	56·9	48 22 16·5	24·4
−100	315 12 53·1	54·9	48 45 55·5	22·9
0	316 1 33·3	52·9	49 9 55·2	21·3
+100	316 50 18·1	50·8	49 34 14·2	19·8

XV. *b.* ξ Pegasi.

−300	313 7 22·1	−4 36·1	+ 1 28 47·2	+18 15·3
−200	314 22 24·6	30·5	1 51 59·3	17 22·1
−100	315 37 22·2	24·0	2 15 43·0	16 29·3
0	316 52 14·2	16·9	2 39 57·7	15 36·8
+100	318 7 0·1	9·1	3 4 42·7	14 44·7

XVI. ι Andromedæ.

−300	328 17 6·4	−0 13·3	+31 12 33·0	−0 57·2
−200	329 22 6·6	12·4	31 41 19·5	54·6
−100	330 27 18·2	11·5	32 10 25·1	52·0
0	331 32 43·0	10·6	32 39 49·7	49·4
+100	332 38 21·0	9·8	33 9 32·1	46·8

XVII. η Cassiopeiæ.

−300	343 28 8·3	−56 35·0	+45 7 28·4	+18 6·0
−200	344 34 21·0	54 35·0	45 39 51·5	17 6·4
−100	345 41 4·1	52 31·0	46 12 24·8	16 8·4
0	346 48 21·0	50 24·0	46 45 5·8	15 11·0
+100	347 56 13·4	48 14·0	47 17 57·0	14 16·0

XVIII. *a.* α Trianguli.

−300	357 40 30·8	−1 21·8	+17 10 39·0	+7 47·9
−200	358 55 54·8	18·2	17 44 21·9	26·1
−100	0 11 35·9	14·6	18 18 4·6	4·3
0	1 27 34·6	10·0	18 51 46·9	6 42·5
+100	2 43 52·3	7·4	19 25 27·1	20·7

XVIII. *b.* γ Arietis.

−300	358 19 51·2	−2 42·2	+6 54 23·1	+2 57·8
−200	359 35 31·3	34·8	7 28 6·5	49·5
−100	0 51 20·2	27·4	8 1 49·8	41·3
0	2 7 18·5	20·0	8 35 31·6	33·0
+100	3 23 27·3	12·7	9 9 10·7	24·8

XIX. β Persei.

−300	13 8 6·5	+0 14·3	+29 54 29·4	−0 7·1
−200	14 28 27·6	13·7	30 27 17·6	6·8
−100	15 49 25·3	13·1	30 59 53·0	6·5
0	17 11 1·2	12·5	31 32 14·2	6·2
+100	18 33 16·0	11·9	32 4 20·7	6·0

XX. *d* Persei.

−300	27 39 26·4	−0 44·9	+37 40 36·5	+2 4·5
−200	29 7 35·3	42·2	38 10 22·0	1 58·9
−100	30 36 36·7	39·5	38 39 41·0	53·3
0	32 6 31·9	36·8	39 8 32·5	47·7
+100	33 37 21·6	34·2	39 36 54·5	42·0

XXI. *a.* π_4 Orionis.

−300	43 3 29·6	−3 22·0	+3 26 11·2	+4 34·3
−200	44 20 44·1	3 11·1	3 50 41·7	22·7
−100	45 38 14·1	3 0·2	4 14 39·2	11·1
0	46 55 58·8	2 48·3	4 38 2·9	3 59·5
+100	48 13 59·1	2 38·4	5 0 51·9	47·8

XXI. *b.* π₂ Orionis.

	α′	Δα′	δ′	Δδ′
—300	43° 1′ 2″·7	—0′ 55″·1	—1° 12′ 17″·5	+0′ 16″·5
—200	44 16 24·4	52·4	0 47 45·7	16·0
—100	45 31 58·7	49·8	0 23 47·0	15·6
0	46 47 45·5	47·1	—0 0 19·3	15·1
+100	48 3 45·0	44·5	+0 22 33·7	14·7

XXI. *c.* ι Tauri.

—300	42 46 17·5	—3 19·0	+15 2 12·3	+0 25·2
—200	44 8 20·9	3 9·9	15 26 48·7	25·2
—100	45 30 47·6	3 0·8	15 50 50·3	25·2
0	46 53 37·2	2 51·7	16 14 16·0	25·2
+100	48 16 50·5	2 42·5	16 37 5·0	25·1

XXII. *a.* χ₄ Orionis.

—300	57 31 30·3	—0 36·7	+16 38 10·0	+0 10·1
—200	58 55 53·8	35·0	16 56 4·6	9·9
—100	60 20 37·7	33·2	17 13 15·3	9·7
0	61 45 41·5	31·5	17 29 41·8	9·5
+100	63 11 4·6	29·7	17 45 22·6	9·2

XXII. *b.* α Leporis.

	α′	Δα′	δ′	Δδ′
—300	58° 11′ 18″·3	—2′ 25″·5	—22° 4′ 58″·6	—0′ 54″·7
—200	59 15 29·9	2 18·9	21 47 18·7	51·1
—100	60 19 46·9	2 12·3	21 30 12·8	47·6
0	61 24 9·5	2 5·7	21 13 40·7	44·0
+100	62 28 37·6	1 59·2	20 57 43·2	40·5

XXIII. *a.* ζ Geminoram.

—300	71 53 48·4	—0 32·3	+20 18 13·4	—0 2·4
—200	73 21 31·0	30·8	28 27·7	2·0
—100	74 49 29·0	29·4	37 51·3	1·7
0	76 17 40·1	27·9	46 23·9	1·3
+100	77 46 4·1	26·5	54 5·0	1·0

XXIII. *b.* ζ Canis majoris.

—300	73 16 9·9	—1 4·9	—31 23 53·0	—0 55·7
—200	74 12 15·6	1 2·3	31 14 16·3	52·6
—100	75 8 26·3	0 59·8	31 5 2·3	49·5
0	76 4 42·0	0 57·2	30 56 41·8	46·4
+100	77 1 2·2	0 54·7	30 48 44·0	43·3

Ces Tables–Ephémérides nous fourniront maintenant tous les renseignements numériques dont nous aurons besoin pour replacer idéalement sur la sphère céleste les indications astronomiques contenues dans le texte d'Hipparque que nous avons donné auparavant.

Selon l'Almageste, où un très grand nombre des observations faites par Hipparque est conservé, on peut juger que l'époque de son activité astronomique tombe entre —159 et —124. En effet, en adoptant dans le tableau suivant le commencement de l'année —140 comme époque, nous avons trouvé que la première étoile, η Canis maj., était alors exactement sur le colure du solstice d'été.

Noms des Étoiles.	Déclinaison calculée pour —140.	Ascens. dr. selon Hipparque.	Ascension dr. calculée pour —140.		Précession annuelle à l'époque.	$A_1 - A$.	$A_2 - A$.
			Sans Mouvem. pr.	Avec Mouvem. pr.			
		A	A_1	A_2			
η Canis maj. .	—27° 10′	90° 0′	89° 59′·2	89° 59′·9	+0′·585	— 0′·8	— 0′·1
ζ Hydræ, . .	+11 46	105 0	104 54·8	104 57·0	0·825	— 5·2	— 3·0
θ Ursæ maj. .	+58 34	105 0	101 36·7	102 24·6	1·273	—203·3	—155·4
ν Leonis, . .	+20 46	119 45	119 42·1	119 42·6	0·870	— 2·9	— 2·4
b Leonis, . .	+30 39	135 0	135 28·6	135 28·0	0·898	+ 28·6	+ 28·0
β Virginis, .	+13 13	150 0	149 52·8	149 40·0	0·805	— 7·2	— 20·0
δ Ursæ maj. .	+68 37	150 45	151 31·7	151 17·8	1·180	+ 46·7	+ 32·8
ε Virginis, .	+22 48	166 30+	168 20·7	168 29·9	0·783	—	—
δ Virginis, .	+15 18	166 30+	166 35·4	166 51·8	0·772	+ 5·4	+ 21·8
φ Centauri, .	—30 32	180 0	180 1·7	180 3·4	0·757	+ 1·7	+ 3·4
τ Bootis, . .	+28 57	180 45	180 43·0	180 59·7	0·747	— 2·0	+ 14·7
γ Bootis, . .	+48 49	195+	195 48·5	195 49·9	0·653	—	—
α₁ Libræ, . .	— 5 31	194 30	194 16·7	194 19·8	0·765	— 13·3	— 10·2

Noms des Étoiles.	Déclinaison calculée pour —140.	Ascens. dr. selon Hipparque.	Ascension dr. calculée pour —140.		Précession annuelle à l'époque.	$A_1 - A$.	$A_2 - A$.
			Sans Mouvem. pr.	Avec Mouvem. pr.			
		A	A_1	A_2			
α Serpentis, .	+15° 5′	210° 0′	210° 16′·8	210° 10′·9	+0′·717	+16′·8	+10·9
μ Serpentis, .	+ 5 10	210 0	210 12·5	210 14·6	0·742	+12·5	+14·6
β Coronæ, . .	+38 3	210 30	209 48·2	209 53·0	0·625	—41·8	—37·0
δ Scorpii, . .	—14 11	210 30	209 57·8	209 57·7	0·802	—32·2	—32·3
β Herculis, .	+28 7	225 0	224 47·9	224 50·8	0·630	—12·1	— 9·2
φ Herculis, .	+51 57	225 30	225 43·3	225 48·2	0·448	+13·3	+18·2
π Herculis, .	+40 59	240 0	240 26·3	240 26·1	+0·503	+26·3	+26·1
[β Ursæ min. .	+82 8	240 0	241 3·3	241 14·7	—1·377	+63·3	+74·7]
[γ Ursæ min. .	+78 58	240 0	241 12·6	241 4·2	—0·742	+72·6	+64·2]
β Ophiuchi, .	+ 8 0	240 0	239 48·3	239 48·4	+0·718	—11·7	—11·6
π Sagittarii, .	—21 17	255 30	255 30·7	255 30·9	0·885	+ 0·7	+ 0·9
γ Aquilae, .	+ 7 48	270 45	271 6·8	271 5·0	0·713	+21·8	+20·0
α Delphini, .	+10 27	285 0	285 3·5	285 0·2	0·700	+ 3·5	+ 0·2
θ Capricorni, .	—23 17	285 0	285 23·0	285 19·6	0·900	+23·0	+19·6
ε Pegasi, . .	+ 1 34	300 0	299 37·0	299 36·1	0·748	—23·0	—23·9
η Cephei, . .	+54 27	300 0	299 45·6	299 24·8	0·357	—14·4	—35·2
ζ Cephei, . .	+48 37	315 0	314 53·4	314 52·5	0·487	— 6·6	— 7·5
ξ Pegasi, . .	+ 2 27	314 30	315 7·4	315 3·0	0·752	+37·4	+33·0
ι Androm., .	+31 58	330 45	330 1·2	330 1·0	0·652	—43·8	—44 0
η Cassiop., . .	+46 16	345 0	345 14·4	344 21·0	0·688	+14·4	—39·0
α Trianguli, .	+18 12	0 0	359 41·3	359 40·0	0·758	—18·7	—20·0
γ Arietis, . .	+ 7 51	0 45	0 21·0	0 18·5	0·760	—24·0	—26·5
β Persei, . .	+30 47	15 0	15 17·0	15 17·2	0·812	+17·0	+17·2
d Persei, . .	+38 30	30 0	30 0·9	30 0·2	0·892	+ 0·9	+ 0·2
π_4 Orionis, . .	+ 4 9	45 0	45 7·2	45 4·1	0·777	+ 7·2	+ 4·1
π_3 Orionis, . .	— 0 33	45 0	45 1·7	45 0·9	0·757	+ 1·7	+ 0·9
ι Tauri, . .	+15 42	45 0	44 57·8	44 54·7	0·827	— 2·2	— 5·3
χ_4 Orionis, . .	+17 7	60 0	59 46·7	59 46·1	0·848	—13·3	—13·9
α Leporis, . .	—21 38	60 0	59 54·0	59 51·8	0·645	— 6·0	— 8·2
ζ Geminorum, .	+20 34	74 30	74 14·3	74 13·8	0·880	—15·7	—16·2
ζ Canis maj. .	—31 10	75 0	74 45·9	74 44·9	+0·563	—14·1	—15·1

Ces chiffres parlant pour eux-mêmes, je me bornerai aux remarques suivantes. Il est bien possible que je n'aie pas réussi à identifier certaines étoiles, mais il est plus probable que le texte grec en quelques endroits est tellement corrompu que les fins des différentes parties aient changé de place. Ayant seulement eu l'occasion de me servir des deux éditions imprimées, ce serait d'un grand intérêt, si le grand nombre de manuscrits éparpillés partout dans les bibliothèques pourrait être comparé avec ce traité. Dans l'état actuel on peut prouver que les Astronomes d'Alexandrie ont pu déterminer le temps sidéral presqu' à une minute près.

OBSERVATION OF THE SPECTRUM OF COMET 1880 *f* (Pechüle) AT DUN ECHT.

(Communicated by the Earl of CRAWFORD and BALCARRES.)

Bad weather entirely prevented observations before December 27, by which time the comet was but two-thirds as bright as when first discovered. The usual three bands were seen with the Grubb prism, but the first and third were excessively faint; indeed the whole spectrum was disappointingly feeble, even when full allowance was made for the not very clear state of the sky and bad definition. The wave-lengths are derived from comparisons with an end-on hydrogen tube illuminated by four Grove pint cells. The final results are :—

1880, Dec. 27.	1st band-maximum.	2nd band-maximum.	3rd band-maximum.
	mmm.	mmm.	mmm.
Wave length, . .	556·6	519·0	472·9
No. of Observations, .	2	4	2

RALPH COPELAND.

CIRCULAR FROM THE SMITHSONIAN INSTITUTION.

Professor Baird has issued a circular to directors of public and private Observatories, informing them that it is intended to present in the Annual Report of the Smithsonian Institution a yearly summary of the state and progress of Astronomy in the United States and elsewhere. To this end it is requested that replies to the circular should be sent *without delay* to Professor E. S. Holden, Naval Observatory, Washington, D.C. A copy of the whole report will be sent to each observatory from which a reply to the circular has been received.

The replies are to state:

Location and name of observatory, longitude and latitude (with authority), personnel. Instruments, first meridian circle (makers, diameter of circles, divided to . . . , microscopes reading to . . . , aperture of object glass, power generally used), next transit instruments, then equatoreal instruments (makers, aperture, power), spectroscopes, photometers, chronographs, clocks, chronometers, &c.

Observations made during the year 1880, stating the subject of observations with each instrument.

Work proposed for the year 1881.

Principal publications in 1880.

Although most British observatories publish annual reports in the "Monthly Notices," and most German ones in the "Vierteljahrsschrift," we hope that the above invitation will be cordially responded to. The reports from American observatories collected by Professor Holden in the "Annual Record of Science and Industry," gave a very complete picture of the state of practical Astronomy in the United States, and a collection of reports from observatories in all countries, like the one proposed in Professor Baird's circular, will be of great interest and prevent much unnecessary duplication of work.

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RECHERCHES SUR L'ASTRONOMIE DES ANCIENS.

PAR H. C. F. C. SCHJELLERUP.

II. *On the Total Solar Eclipses Observed in China in the Years* B.C. 708, B.C. 600, *and* B.C. 548.[*]

In Chun-Tsiew, one of the Vu-king or canonical books of the Chinese which are ascribed to Confucius, is given a short review of the most remarkable events which took place from B.C. 721 to B.C. 480 at the court of the then existing principality of Lu. Whether Chun-Tsiew (published in Vol. 5 of Dr. Legge's "Chinese Classics," 1872) really has been written by Confucius or not is doubtful, but not of much importance as regards the reliance to be placed on it. It is mentioned by the philosopher Mang-tse, who lived a century after Confucius, as having been written by the latter (who was a native of Lu), so it must, at any rate, have been written during his time. The principal events are besides corroborated by three commentaries.

Chun-Tsiew means "Spring and Harvest," a title which, according to a peculiarity of the Chinese language, must be considered simply as an abbreviation of "Spring, Summer, Autumn, and Winter," and might therefore best be translated as "Annals." The events are noted in yearly groups, each of which is divided into four parts according to the seasons. The dates are always given thus: first the year of the reign of the prince, then the season, the month, and lastly the cyclical denomination of the day.

In the Chinese canonical books 38 solar eclipses in all are mentioned; one in Shu-King, perhaps B.C. 2155, one in Shi-King, B.C. 776, and 36 in Chun-Tsiew. These latter can be easily identified by means of Pingré's list of eclipses from B.C. 1000 to the birth of Christ in "L'Art de vérifier les dates," and the result of this comparison is, that two of the eclipses did not take place. A closer investigation shows that they could not have taken place, as they are described as having happened about a month after a real eclipse must have occurred. Some clerical error must have crept even into the earliest copies, as these spurious eclipses are mentioned by old Chinese authors who well knew that they were impossible, and at most hinted that such things might possibly have occurred in former days. Probably the year is wrong, and in the case of two other eclipses something similar must have happened, where, however, plausible corrections have been suggested. Of the remaining 32 eclipses, 18 agree with Pingré's list as regards the year, the month, and the day, while the rest are correct as to year and day, but are one, two, or three months wrong. This, however, probably arises only from our defective knowledge of the ancient Chinese calendar, particularly of the intercalation and the beginning of the year, which possibly were subject to great irregularities. The indication of the day was simple enough, and its being always correct proves sufficiently how reliable the records are.

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[*] At the request of the author we have translated a paper published six years ago in the Proceedings of the Royal Danish Society of Sciences, and given it a place among his French papers on the Astronomy of the Ancients. We felt fully justified in doing so, as the paper is no doubt unknown to almost all our readers, and will be read with particular interest at the present moment.—EDITORS.

From these 36 solar eclipses I have selected three which are described as total, viz., B.C. 708, July 16, B.C. 600, Sept. 19, and B.C. 548, June 18. See Legge's edition of the "Chinese Classics," Vol. 5, pp. 41, 301, and 304.

The first one is stated to have occurred in the third year of the reign of Hwan, in harvest, in the seventh month, on the day Iin-shin. The day is correct but the month should be the eighth.

The second occurred in the autumn of the eighth year of Siuen, in the seventh month, on the day Kia-tse. The day is correct but the month should be the tenth, or the first of the winter. The mistake arises probably from the account of the next event beginning thus: In the winter in the tenth month, &c.

Lastly, the third eclipse took place in the 24th year of Siang, in the autumn, in the seventh month, on the day Kia-tse. This date is quite right. Confucius was at that time three years old.

These eclipses were undoubtedly not mentioned with any scientific intention, but only because they were considered as bad omens. I have, however, treated them as exact observations, simply on account of their being total, as they hereby become of great importance, even though not exactly determined as to time, if only the place of observation is known. Though the latter is not mentioned, there is every reason to suppose that the phenomena were observed not only within the borders of the principality of Lu, but probably even in the metropolis, the geographical position of which is well known. By comparing Dr. Legge's map of ancient China with a modern one it will be seen that Lu formed the southern part of the present province of Shan-tung in the East of China, bordered on the south side by the southern arm of Hvang-ho. It was situated between 34°·5 and 36°·3 north latitude, and between 115°·5 and 119° east longitude from Greenwich. The metropolis was called Kiu-fau, and its geographical position was, according to Biot's "Dictionnaire des noms anciens et modernes des villes et arrondissements de l'empire Chinois," p. 65—

$$\phi = +\ 35^\circ\ 52'$$
$$\lambda = 117^\circ\ 13' \text{ (Greenwich).}$$

Calculation of three Chinese eclipses by means of Hansen's tables of the Sun and Moon, used without any correction whatever.

I. B.C. 708, JULY 16.

Gr. M. T.	☾ Long.	☾ Lat.	Eq. Hor. Par.	Sun's Long.
$17^h\ 0^m$	105° 13′ 46″·7	+ 36′ 2″·7	60′ 39″·1	105° 59′ 54″·5
18 0	105 50 54·2	32 38·9	60 38·3	106 2 17·4
19 0	106 28 2·2	29 13·7	60 37·3	106 4 40·3

Besides, for 18 0^m—

Log Rad. v. = 0·004840

⊙ Eq. Hor. Par. = 8″·75. App. obl. of ecl. = 23° 47′ 21″·6

Equation of Time = Sid. T. — ⊙ app. RA = + 31^s·84

From this we find—

Moment of conjunction = July 16, 18^h·32763 Gr. M. T., to which corresponds (using Hansen's notation)—

$l = l'$ = 106° 3′ 4″·2	b = + 31′ 31″·7	π = 60′ 37″·9
μ = 276°·3700	α' = 107° 27′ 16″·4	δ' = + 22° 48′ 30″·0
h = − 6° 56′ 57″·7	N = 95° 37′ 14″·2	G = 119° 54′ 27″·5
K = 94° 56′ 25″·0	Log sin g = 9·639968	Log sin k = 9·991080

By means of these results the following table was computed, which for each hour-angle gives the corresponding point of the curve of central eclipse—

CURVE OF CENTRAL ECLIPSE.

t	λ	ϕ
40°	114° 25′	+ 44° 23′
42	115 43	43 35
44	117 2	42 46
46	118 22	41 55
48	119 42	41 4
50	121 2	40 10
52	122 22	39 16
54	123 43	38 20
56	125 5	37 24
58	126 27	36 27
60	127 50	35 28

Half the section of the zone of totality by the meridian is 1° 18′, and of the zone of $\frac{11}{12}$ is 5° 31′.

II. B.C. 600, SEPT. 19.

Gr. M. T.	☾ Long.	☾ Lat.	Eq. Hor. Par.	Sun's Long.
18^h 0^m	170° 7′ 22″·2	+ 50′ 11″·3	61′ 14″·3	170° 35′ 10″·5
19 0	170 45 14·3	46 43·6	61 13·8	170 37 36·7
20 0	171 23 5·7	43 15·7	61 13·3	170 40 2·9

For 19^h 0^m Equation of time = + 4^m 20^s·15, Log Rad. v. = 9·997014

⊙ Eq. Hor. Par. = 8″·91, app. obl. = 23° 46′ 35″·7

which gives—

Moment of conjunction = Sept. 19, 18^h·78475 Gr. M. T.,

$l = l'$ = 170° 37′ 5″·2	b = + 47′ 28″·3	π = 61′ 13″·9
μ = 284°·8004	α' = 171° 24′ 7″·0	δ' = + 3° 46′ 6″·0
h = − 23° 29′ 35″·3	N = 95° 34′ 48″·6	G = 173° 15′ 30″·0
K = 92° 5′ 33″·7	Log sin g = 9·689585	Log sin k = 9·941801

CURVE OF CENTRAL ECLIPSE.

t	λ	ϕ
46°	115° 26′	+ 37° 27′
48	116 36	36 16
50	117 48	35 7
52	119 1	34 1

Half the section of the zone of totality by the meridian is 1° 47′.

III. B.C. 548, June 18.

Gr. M. T.	☾ Long.	☾ Lat.	Eq. Hor. Par.	Sun's Long.
$16^h\ 0^m$	79° 45′ 29″·2	+ 4′ 30″·4	61′ 8″·9	80° 21′ 43″·7
17 0	80 23 13·3	7 59·9	61 9·5	80 24 7·0
18 0	81 0 58·2	11 29·8	61 10·0	80 26 30·3

For $17^h\ 0^m$ Equation of time = + $5^m\ 36^s$·00.

Log rad. v. = 0·007108, ⊙ Eq. Hor. Par. = 8″·71.

App. obl. = 23° 46′ 6″·7. Moment of conj. = June 18, 17^h·02531.

$l = l' =$ 80° 24′ 10″·6 $b = +$ 8′ 5″·2 $\pi =$ 61′ 9″·5 $\mu =$ 256°·6435

$\alpha' =$ 79° 31′ 56″·5 $\delta = +$ 23° 24′ 57″·3 $h = +$ 4° 11′ 57″·2

N = 84° 20′ 55″·3 G = 66° 23′ 52″·0 K = 86° 3′ 9″·0

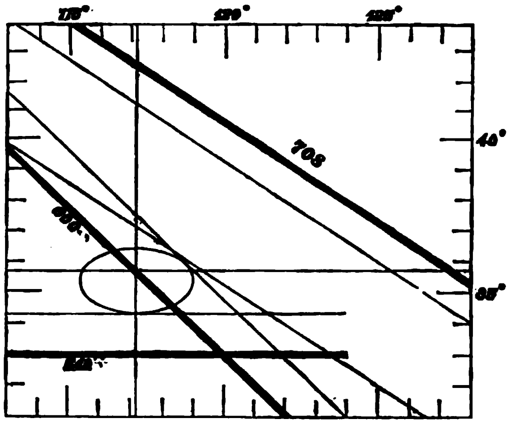
Log sin g = 9·630719 Log sin k = 9·994580

Curve of Central Eclipse.

t	λ	ϕ
18°	113° 59′	+ 32° 58′
21	115 54	33 2
24	117 51	33 3
27	119 48	33 1

Half the section of the zone of totality by the meridian = 1° 9′.

The annexed woodcut shows that these three curves do not all pass through the principality, *i.e.*, they do not fulfil the condition that the three eclipses should all have been total at one place.



As regards the meridian of the metropolis matters stand thus. The curve 600 intersects it in a point only 11′ south of the city, but as half the zone of totality here is 1° 47′ along the meridian, this eclipse must have been total at Kiu-fau. The hour-angle was between 48° and 50°. But the two other curves intersect the meridian of the city in points which are respectively 6° 18′ north (708) and 2° 38′ south (600) of the same. But when we remember that the latter curve is very nearly a parallel and that half the breadth of the zone of totality is 1° 9′, we see that the eclipse of B.C. 548, though not total for Lu, must have been nearly so, as the north limit of totality passed within about 25 English miles of the frontier of Lu. If this eclipse should have been total for the metropolis, some element must be corrected so as to bring the curve of central eclipse 1° 41′ to the north.

In the same way we see that the eclipse of 708 cannot be made total for any place in Lu without moving its curve about 5° to the south.

In order to be able to judge whether some element could be varied so as to move the two curves without the eclipse of B.C. 600 ceasing to be total, I have computed differential formulæ, which, for variations in the mean longitude and the longitude of the node, give the variation of the latitude of the point of intersection between the curve and the meridian of the metropolis—

$$\begin{aligned} &\text{B.C. } 708 \quad \delta\phi = 16{\cdot}77\,\delta l + 8{\cdot}13\,\delta\Omega \\ &\text{B.C. } 600 \quad \delta\phi = 22{\cdot}35\,\delta l + 12{\cdot}58\,\delta\Omega \\ &\text{B.C. } 548 \quad \delta\phi = -0{\cdot}27\,\delta l - 5{\cdot}23\,\delta\Omega \end{aligned}$$

These formulæ show that the three curves can only be suitably shifted by putting $\delta l = 0$ and making $\delta\Omega$ negative. As the eclipse of B.C. 600 has to remain total, $\delta\Omega$ cannot be taken larger than — 7′·5 so that the correction to the secular motion of the lunar node does not exceed 18″·3.* The eclipse of B.C. 548 will then have been total inside the frontier of Lu, the northern limit of totality passing 1° south of the city, while the southern limit for the eclipse of B.C. 708 is only moved 62′ nearer to the metropolis, thus passing 3° 58′ north of it. However, the city will be inside the curve of the $\frac{11}{12}$ phase.

Calculation of the three eclipses, adopting Adams' and Delaunay's value for the secular acceleration of the Moon's mean motion.

I. B.C. 708, July 16.—Adopting also some minor corrections in accordance with Hansen, a change of — $6''t^2$ in the mean longitude will (Darlegung, II., p. 394 and foll.) correspond to—

$$\delta z = -0{\cdot}0659498 \qquad \delta\Pi = -0^\circ{\cdot}231063 \qquad \delta\omega = -0^\circ{\cdot}153287$$

which involve the following corrections to the longitude, latitude and equatoreal horizontal parallax—

$$\delta l = -1^\circ\ 10'\ 22''{\cdot}7 \qquad \delta b = +5'\ 52''{\cdot}0 \qquad \delta\pi = +1''{\cdot}7$$

The conjunction, therefore, took place on July 16, $20^{h}{\cdot}35250$, Gr. M. T., for which epoch we have—

$$\begin{array}{lll} l = l' = 106^\circ\ 7'\ 53''{\cdot}6 & b = +30'\ 26''{\cdot}0 & \pi = 60'\ 37''{\cdot}5 \\ \mu = 306^\circ{\cdot}7062 & \alpha' = 107^\circ\ 32'\ 28''{\cdot}1 & \delta' = +22^\circ\ 47'\ 54''{\cdot}8 \\ h = -6^\circ\ 58'\ 58''{\cdot}5 & N = 95^\circ\ 39'\ 46''{\cdot}1 & G = 120^\circ\ 4'\ 18''{\cdot}0 \\ K = 94^\circ\ 58'\ 7''{\cdot}5 & \text{Log sin } g = 9{\cdot}640382 & \text{Log sin } k = 9{\cdot}990971 \end{array}$$

CURVE OF CENTRAL ECLIPSE.

t	λ	ϕ
82°	113° 56′	+ 23° 2′
84	115 40	22 3
86	117 26	21 5

It will now pass about 15° south of the metropolis.

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* According to § 320 of Hansen's "Darlegung" a change of 12″ in the secular motion of the node will produce a change of ± 1″ in the latitude of the Moon at the time of Bradley. Considering that Sir G. B. Airy (Phil. Trans., 1853) does not attach great weight to Bradley's declinations, the above correction of 18″·3 cannot be considered unreasonable.

II. B.C. 600, Sept. 19. $\delta z = -0{\cdot}0606192$, $\delta\Pi = -0^\circ{\cdot}21150$, $\delta\omega = -0^\circ{\cdot}14031$, $\delta l = -1^\circ\ 5'\ 19''{\cdot}8$, $\delta b = +5'\ 25''{\cdot}4$, $\delta\pi = +0''{\cdot}8$. Moment of conjunction = 19 Sept., $20^{\mathrm{h}}{\cdot}62912$, Gr. M. T., to which correspond—

$l = l' = 170^\circ\ 41'\ 34''{\cdot}9$ $b = +46'\ 30''{\cdot}3$ $\pi = 61'\ 13''{\cdot}8$
$\mu = 312^\circ{\cdot}4294$ $a' = 171^\circ\ 28'\ 15''{\cdot}0$ $\delta' = +3^\circ\ 45'\ 51''{\cdot}5$ $h = -23^\circ\ 28'\ 51''{\cdot}6$
$N = 95^\circ\ 35'\ 14''{\cdot}5$ $G = 173^\circ\ 16'\ 7''{\cdot}4$ $K = 92^\circ\ 5'\ 29''{\cdot}3$
$\text{Log}\sin g = 9{\cdot}689740$ $\text{Log}\sin k = 9{\cdot}941751$

Curve of Central Eclipse.

t	λ	ϕ
83°	114° 10′	+ 21° 17′
85	116 0	20 58
87	117 53	20 42

As this curve also passes about 15° south of the city, it will intersect the other curve very near the meridian of the city.

III. B.C. 548, June 18. $\delta z = -0{\cdot}0580059$, $\delta\Pi = -0^\circ{\cdot}20244$, $\delta\omega = -0^\circ{\cdot}13430$, $\delta l = -1^\circ\ 2'\ 41''{\cdot}5$, $\delta b = -5'\ 15''{\cdot}1$, $\delta\pi = -0''{\cdot}9$. Moment of conj. = 18 June, $18^{\mathrm{h}}{\cdot}79826$, Gr. M. T., for which moment we find—

$l = l' = 80^\circ\ 28'\ 24''{\cdot}7$ $b = +9'\ 2''{\cdot}5$ $\pi = 61'\ 9''{\cdot}6$ $\mu = 283^\circ{\cdot}1980$
$a' = 79^\circ\ 36'\ 32''{\cdot}6$ $\delta' = +23^\circ\ 25'\ 15''{\cdot}7$ $h = +4^\circ\ 1'\ 7''{\cdot}5$. $N = 84^\circ\ 20'\ 55''{\cdot}3$
$G = 66^\circ\ 28'\ 7''{\cdot}0$ $K = 86^\circ\ 3'\ 51''{\cdot}0$ $\text{Log}\sin g = 9{\cdot}630616$ $\text{Log}\sin k = 9{\cdot}99416$

Curve of Central Eclipse.

t	λ	ϕ
56°	113° 28′	+ 30° 37′
59	115 43	29 59
62	118 0	29 16
65	120 18	28 31

This curve now passes about 6° south of the metropolis.

The southward shifting along the meridian of the city is remarkably large, especially in the cases of the two first eclipses. We learn, therefore, from these eclipses what other eclipses have also led us to suppose, namely, that the new acceleration is quite insufficient to represent the positions of the Moon some thousands of years ago. It has been suggested that the discrepancy between the theoretical and observational values of the acceleration is due to a retardation of the sidereal day caused by the tides. Supposing this explanation to be the true one, I have attempted to determine the amount of this retardation by means of the Chinese eclipses.

Prolonging the three last curves until they intersect the parallel of the principality, I find—

B.C. 708, July 16.			B.C. 600, Sept. 19.			B.C. 548, June 18.		
t	λ	ϕ	t	λ	ϕ	t	λ	ϕ
46°	87° 37′	+ 40° 31′	36°	81° 31′	+ 41° 54′	14°	84° 53′	+ 33° 40′
48	88 57	39 37	39	83 12	39 58	17	86 47	33 49
50	90 17	38 43	42	84 53	38 5	20	88 43	33 55
52	91 37	37 48	45	86 36	36 15	23	90 40	33 57
54	92 58	36 53	48	88 22	34 32	26	92 38	33 56
56	94 20	35 57	51	90 10	32 52	29	94 36	33 52
58	95 42	34 59	54	92 2	31 17	32	96 37	33 44
60	97 4	34 1	57	93 58	29 48	35	98 38	33 33
			60	95 59	28 28	38	100 41	33 18
						41	102 50	33 0

Where these curves cross the parallel we may draw a figure of the same size as Lu, and so placed that its position with regard to one of the curves satisfies the same conditions as in the first calculation.

The point in this figure which could represent the metropolis would then, if referred to the eclipse of B.C. 600, be situated in long. 87° 11′ E. of Greenwich. As the longitude of the city is 117° 13′ E., the difference of longitude, 30° 2′ or $2^h\,0^m\,8^s$ is the amount by which the sidereal day has been retarded between B.C. 600 and A.D. 1800. The *time* must accordingly be corrected by—

$$-12^s{\cdot}514\ t^2,$$

where t is the number of centuries elapsed since 1800.

Calculation of the three eclipses after applying a correction of — 36″ to Hansen's secular motion.[*]

I. — 708, $\delta l = +\ 16'\ 27''{\cdot}0$, $\delta b = -\ 1'\ 28''{\cdot}2$.

The conjunction, therefore, took place on July 16, $19^h{\cdot}87927$ Gr. M. T., to which corresponds—

$$l = l' = 106^\circ\ 6'\ 46''{\cdot}0 \qquad b = +\ 30'\ 35''{\cdot}7 \qquad \pi = 60'\ 38''{\cdot}0.$$

The curve resulting from this is found from the one given on p. 46, by adding to λ and ϕ respectively + 7° 9′ and + 13′.

II. — 600, $\delta l = +\ 15'\ 57''{\cdot}2$, $\delta b = -\ 1'\ 25''{\cdot}2$. Conj. Sept. 19, $20^h{\cdot}17871$ Gr. M. T.; $l = l' = 170^\circ\ 40'\ 29''{\cdot}0$, $b = +\ 46'\ 39''{\cdot}7$, $\pi = 61'\ 14''{\cdot}0$. Corrections to curve on p. 46, are + 6° 51′ and + 16′.

III. — 548. $\delta l = +\ 15'\ 36''{\cdot}4$, $\delta b = +\ 1'\ 24''{\cdot}2$. Conj. June 18, $18^h{\cdot}35690$, Gr. M. T.; $l = l' = 80^\circ\ 27'\ 21''{\cdot}5$, $b = +\ 8'\ 53''{\cdot}8$, $\pi = 61'\ 9''{\cdot}3$, and accordingly $\delta\lambda = +\ 6^\circ\ 36'$, $\delta\phi = -\ 8'$.

The above difference of longitude will now be diminished by 7° 7′. The resulting

$$\text{Retardation of the sidereal day} = 9^s{\cdot}549\ t^2$$

must be considered as the most probable value. Each sidereal day will accordingly be—

$$0^s{\cdot}00000001423$$

longer than the previous one, and the day was 2400 years ago $0^s{\cdot}01252$ shorter than at present.

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[*] See Sir G. Airy's paper in the "Monthly Notices," vol. XXXIV., No. 1.

THE U. S. NAVAL OBSERVATORY DURING THE YEAR ENDING OCTOBER 31, 1880.

(From the Report of Rear-Admiral JOHN RODGERS, to the Chief of the Bureau of Navigation, Navy Department.)

Professor Hall and his assistants continue their observations of Satellites, Double-stars and Nebulæ, with the 26-in. equatoreal. The instrument is in good order, but the dome and driving clock have needed repairs.

Professor Eastman has charge of the transit-circle and the distribution of time. 4,140 observations were made, based on the stars of the American Ephemeris. Besides the routine work observations were made of Transit of Venus Expeditions' occultation-stars; standard stars for a zone; all B.A.C. stars between 120° and 131° 10′ N.P.D. that had not been observed three times in both co-ordinates at Washington; comparison-stars for the equatoreal observations, and lastly stars used in American surveys.

The printing of the annual volume for 1876 is nearly finished; the subsequent volumes are either ready for the printer or are far advanced, but there is a want of funds, for which an urgent appeal is made.

Professor Eastman has also observed comets and occultations with the 9·6-in. equatoreal, besides rectifying ephemerides of minor planets not readily found with the transit-circle.

In addition to superintending the reduction of the Ann Arbor photographs of the 1878 Transit of Mercury, Professor Harkness is making various Experiments in Astronomical Photography, of which we may mention those to find the best form of apparatus for photographing the solar corona.

The publication of the Reports on the Solar Eclipses of July 29, 1878, and January 11, 1880, has been ordered by Congress. The stereotyped volume of 440 pages contains 35 cuts and 30 lithographed plates. It cannot fail to be of the greatest interest. It has been carried through the press and indexed by Professor Harkness.

The Transit of Venus results are partly in the hands of the printer, but here again additional funds are needed.

The library, containing 8,500 volumes was in charge of Professor Holden. A catalogue consisting of about 16,000 cards is complete. The books are placed in various rooms and passages where, as is pointed out, the danger from fire is very great; this is the more to be regretted as "many of them could not be replaced if once lost by fire."

The observatory publications are presented wholly or in part to 921 correspondents; since February, 1879, about 12,000 separate numbers of publications have been distributed, mostly to complete sets.

It is proposed to make special provision for extending the testing of chronometers to extreme temperatures.

A special clock has been arranged for distributing time. Time-balls have been dropped both at Washington and New York with respectively two and nine failures from *all* causes in the year. Meteorological observations are made by the watchmen every three hours, beginning at midnight.

COMPARISON STARS.

A suggestion to Astronomers.

In spite of the numerous star-catalogues in the hands of observers of minor planets and comets, it frequently happens that a well-determined place for a comparison star cannot be found in any catalogue. Many stars have therefore yearly to be re-observed, and much time is no doubt lost by a number of observers each having to determine the places of a few stars, which if put together in one working list could be observed by one person with but little trouble.

It would evidently be an advantage if an astronomer, having at his disposal a good transit circle, would, for a time, endeavour to determine the places of all the comparison stars recently used and requiring re-observation.

In accordance with this scheme I shall until further notice (with the concurrence of Dr. Ball) be glad to determine with the Dunsink Transit Circle the places of any comparison stars north of — 20° Declination not found in modern catalogues, and recently used in observations of minor planets or comets. The mean places, based on the Fundamental Catalogue of the "Astronomische Gesellschaft," will be worked out and published as soon as practicable.

J. L. E. Dreyer.

Dunsink Observatory,
February, 1881.

CORRECTIONS TO DR. BÖRGEN'S PAPER ON OCCULTATIONS.

Page 9, lines 11 and 12 from end, should be—

$$\log \rho \sin \phi' = \log (1 - e^2) + \log \sin \phi - \log \cos \psi$$
$$\log \rho \cos \phi' = \log \cos \phi - \log \cos \psi$$

The table on page 10 is computed from the correct formulæ.

[The errors were in the original MS.—Ed.]

NEW NEBULÆ.

By A. AINSLIE COMMON.

I give below the approximate places of some new nebulæ found in 1880 with the 36-inch reflector. Some of them seem worth re-examination, which might be done now, as they are conveniently placed. The positions are obtained from the circles of the instrument, but may be near enough for identification. Almost in every case the objects have been seen on more than one night.

No.	R.A.	Dec.	Remarks.
1	10^h 4^m 10^s	− 12° 4′	S, F, just south of G. C. 2023, and possibly the p one alluded to but not given.
2	10 26 30	− 11 53	F double neb with 2 stellar centres.
3	10 32 47	− 10 45	F, irregular shape, f star.
4	10 38 32	− 10 48	A F pair, f one brighter.
5	10 42 ±	+ 9 14	F, R.
6	10 44 11	− 12 2	F, R.
7	10 44 17	− 11 14	p B, very long, Pos. 270°.
8	10 44 57	− 11 35	2, F, R.
9	10 45 17	+ 9 54	p F, R.
10	10 47 45	− 10 43	e F, R, n of S star.
11	10 52 37	+ 10 0	S, stellar.
12	10 54 ±	+ 9 59	v F, S.
13	11 2 25	− 9 38	2 stars inv in haze, Pos. 160°.
14	11 2 41	− 10 6	Nebulous star, B centre.
15	11 14 35	− 9 37	2 planetary nebulæ, B star between.
16	11 17 49	− 11 24	e F, fan-shaped, star close.
17	11 19 5	− 9 11	p B, L, bM, E 180°.
18	11 23 57	− 10 40	2, F, R, on the parallel, star symmetrically placed between.
19	11 26 33	− 9 17	F, S, R.
20	11 28 15	− 9 11	F, R, a cluster of 3 similar ones 15′ n.
21	11 30 37	− 9 12	F, diffused, sp 7 stars.
22	11 32 25	− 10 0	p B to a Nucl; another 5′ nf, ee F.
23	11 39 5	− 8 33	F, p L, dif, another sf not so L.
24	11 43 15	− 9 6	F, L, diffused.
25	12 11 25	− 9 17	Like a pair of stars 90°; the f one is a neb.*
26	23 7 52	+ 9 35	F, S.
27	23 12 24	+ 9 33	F, R, f 3 stars in a line 90° pointing to another fainter neb s.
28	23 12 28	− 9 16	F, stellar.
29	23 12 43	+ 8 37	p B, diffused. Found in looking for Faye's comet.
30	23 13 28	+ 9 30	F, S, diffused.
31	23 13 56	+ 9 29	p F, diffused.
32	23 15	+ 10 47	F, S neb exactly similar to Faye's comet as seen some 15′ f; on Aug. 8 the comet had moved much closer and a fair comparison could be made, as they were in the same field. The comet (nf the neb) was lbM. There are 2 similar nebulæ within 30′ sf No. 32.

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* Evidently identical with a F neb. f * 14^m and 50^s f, 4′ n of B.W. 12^h, 183. Found by Tempel in 1876, A.N. 2212.—J. L. E. D.

POSITIONS OF NEBULÆ. Series I.

By C. H. F. PETERS.

The positions here presented are derived graphically from my manuscript charts, which have about the scale of Chacornac's. The accuracy thus attained, relatively to direct measurements, increases with the difficulty of the objects. The fainter nebulæ, those of Herschel's Cl. III., can be drawn by allineation between the small neighbouring stars with greater accuracy, than the determination of their places by instrumental measurements seems to permit, except when many times repeated. Since the co-ordinates, by using a subdivided scale, can be read off with ease to one or two-tenths of a minute, I estimate for *faint* nebulæ the probable error to be not much greater than $\pm\frac{1}{3}'$, so that the place lies certainly within the little area subtended by them. For nebulæ of greater brightness and covering a larger area, the graphical method on the contrary loses in comparative advantage, and for those that have a nucleus or condensed centre of light, the micrometrical measurement of course is always superior.

But the manner in which they are obtained, gives positions of this kind a special value, in that they are naturally free from all such accidental mistakes, as are found in the catalogues and originate either in observation or in reduction. Considering especially the imperfect mounting of the Herschelian reflectors for accurate measures, there always remains a certain uncertainty in regard to the position, or to the existence on the indicated place of nebulæ observed only once, so that any check of them is welcome. About half the number in the following list are of this sort.

I have called a nebula *nova*, when not found in Sir John Herschel's "General Catalogue," nor in Mr. Dreyer's Supplement. The epoch is the same as of that catalogue (1860·0), and where the notes have no remark, the difference in position is but slight. It will be remembered that, according to D'Arrest's investigation, the probable error of an observation by Sir John is 15″ in Æ (for the northern catalogue; for the Cape-catalogue a little smaller, only 12″·7), and 19″ in declination. The places of Sir W. Herschel for the years before 1785, in which by far the greater portion of his observations were made, have an error of ±2′·5 in Æ, and of ±1′ 5 in declination.

No of Gen. Cat.	1860·0.		Notes.
	Æ.	Decl.	
211	$1^h\ 0^m\ 11^s$	+ 0° 10′·6	
5150	1 0 56	+ 3 46·6	Æ in G. C. 7^s too small (Marth 35).
238	1 5 46	+ 0 14·0	
5159	1 7 40	+ 1 10·8	Marth 37.
5161	1 8 43	+ 4 26·3	Marth 39.
5162	1 11 1	+ 3 28·6	Æ in G. C. 6^s too small (Marth 40).
263	1 11 54	+ 2 35·0	

No. of Gen. Cat.	1860·0.					Notes.
	Æ.			Decl.		
5164	1^h	12^m	8^s	+14°	9′·8	Decl. in G. C. about 2′ too small (Marth 41).
264	1	12	32	+ 2	39·8	The place in the G. C. had already been corrected by Dreyer from Schultz and D'Arrest.
5165	1	12	36	+14	4·1	Marth 42.
5166	1	12	53	+14	8·4	Æ in G. C. about 15^s too small (Marth 43).
269	1	12	55	+ 2	40·1	This agrees with Dreyer's correction.
5168	1	14	6	+ 3	7·4	Æ in G. C. 7^s too small (Marth 45).
276	1	14	32	+ 4	31·5	
281	1	14	56	+ 0	13·5	
290	1	15	24	+ 4	39·5	
5174	1	16	10	+10	33·7	Stephan VIII.
298	1	16	42	+12	11·0	
303	1	17	22	+ 3	4·7	
304	1	17	22	+ 0	58·2	
315	1	18	18	+ 1	2·2	
326	1	19	32	+ 1	17·0	
366	1	28	52	− 0	3·2	
372	1	29	14	+15	3·0	Messier 74.
375	1	29	56	+ 5	8·0	
5192	1	32	52	+ 5	0·8	Marth 51.
393	1	36	29	+ 3	31·0	
2010	9	59	16	+15	2·8	
2015	10	0	43	+10	40·7	
2026	10	5	22	+13	22·2	Æ in G. Cat. differs about 15^s, as h. 677; but H. III. 53 agrees better.
2091	10	16	16	+13	16·4	
2147	10	28	58	+13	26·6	
2148	10	29	11	+14	53·6	
Nova	10	32	33	+10	2·0	A very faint nebula, and distinct from the following. Both were seen 1880, Mar. 27 and 28.
2170	10	33	11	+ 9	54·6	Schönfeld and Vogel, see Dreyer's Suppl., p. 392.
2175	10	34	43	+14	27·7	
2177	10	35	21	+10	11·0	
2179	10	36	9	+12	43·5	Repeatedly examined; I see two very faint stars, perhaps surrounded by nebula, (? an ellipse with stellar foci). Comp. what Dreyer says in Suppl., p. 392.
2184	10	36	31	+12	26·2	Messier 95.
2193	10	39	9	+14	29·1	
2194	10	39	23	+12	33·6	Messier 96.
2196	10	39	36	+14	31·7	= h 751. Dreyer says: "h 751 and 753 not seen in Birr, Copenhagen, Upsala, and Leipzig (Vogel)." 2196 was distinctly seen by me 1880, Mar. 2; but 2198, the third of the "triple nebula," could not be found.
2201	10	40	17	+14	43·6	
2203	10	40	25	+13	18·5	Méchain.
2207	10	40	54	+13	21·8	
2211	10	41	6	+13	15·6	
2229	10	43	31	+14	8·5	
2240	10	44	42	+10	53·6	
2261	10	48	59	+10	30·1	
2262	10	49	34	+10	30·2	
2276	10	52	54	+14	39·0	
2277	10	53	17	+12	55·4	
2289	10	55	52	+11	49·0	
2303	10	59	12	+12	7·9	
2403	11	16	37	− 0	21·3	
2417	11	18	55	− 5	5·0	

No. of Gen. Cat.	1860·0.					Notes.
	Æ.			Decl.		
2434	11^{h}	22^{m}	54^{s}	+ 10°	1′·6	
2580	11	43	21	+ 7	20·4	
2577	11	43	23	− 4	22·2	Æ in G. C. from 15^{s} to 20^{s} too small, and also the declination differs rather much. The nebula is vL, and not eS, as H. III. 113 has it.
2607	11	46	32	− 3	13·3	
2626	11	48	45	+ 7	31·6	
2647	11	50	55	− 1	20·3	
2673	11	55	12	+ 5	6·6	The NPD in G. C. would be improved by rejecting the first observation of h. 1055, which was only "a rough estimate."
2703	11	57	37	− 1	36·8	
2728	12	0	28	+ 3	27·8	Æ and NPD in G. C. not good.
2733	12	1	2	+ 3	39·7	
5623	12	2	30	+ 2	32·7	D'Arrest's Decl. is over 1′ larger, but he calls the nebula "visu difficilis."
2776	12	5	43	+ 2	4·2	
2777	12	5	56	+ 7	48·8	
Nova	12	6	11	+ 4	49·0	Very small. Seen with a higher power the nebula perhaps may turn out to be only a group of a few very faint stars.
2785	12	6	45	+ 7	58·5	Æ in G. C. 5^{s} smaller, (— star's place for h. 1130?).
2805	12	8	44	+ 7	10·4	
2813	12	9	26	+ 8	13·6	
2823	12	9	57	+ 8	24·1	
2821	12	9	58	+ 7	57·8	
2822	12	9	59	+ 4	27·4	
2829	12	10	16	+ 7	27·3	
5629	12	10	48	+ 6	24·7	Marth 234.
5630	12	11	23	+ 6	21·5	Marth 235.
Nova	12	11	46	+ 5	33·5	S, pm bM.
2840	12	11	57	+ 6	30·0	
2843	12	12	13	+ 6	52·5	
2842	12	12	15	+ 6	36·4	
2844	12	12	18	+ 6	9·7	Æ in G. C. 5^{s}, and Decl. 2′·7 smaller. The only observation, h. 1178, has NPD for 1830, thus: 83° 43′ ±, and the apparent accuracy to tenths of seconds of arc in G. C. is but the result of reduction.
2847	12	12	28	+ 6	37·7	
5632	12	12	39	+ 6	3·9	Schönfeld and D'Arrest.
5070	12	12	42	+ 6	14·8	Schönfeld and D'Arrest.
2849	12	12	43	+ 6	47·4	
2852	12	12	47	+ 6	7·2	
2865	12	12	56	+ 6	7·4	Schultz; see Dreyer's Suppl., p. 393. A very faint nebula indeed.
Nova	12	12	59	+ 8	27·4	pF, pL.
2857	12	13	13	+ 6	9·7	
5633	12	13	13	+ 6	20·7	Decl. in G. C. 2′ too great (Marth 237).
5634	12	13	40	+ 6	24·4	Marth 238.
2870	12	14	7	+ 5	22·3	
2872–3	12	14	20	+ 7	25·6	
2876	12	14	30	+ 6	9·1	
2878	12	14	45	+ 5	15·2	Messier 61.
Nova	12	14	56	+ 9	49·5	pL, not vF.
2892	12	15	58	+ 6	2·4	
2893	12	16	5	+ 6	51·1	
2899	12	16	15	+ 6	49·6	
2904	12	16	28	+ 6	51·2	
2905–6	12	16	29	+ 7	44·5	

No. of Gen. Cat.	1860·0.		Notes.
	Æ.	Decl.	
Nova	$12^h\ 16^m\ 42^s$	$-\ 2°\ 27'·7$	This hardly can be G. C. 2911 (h. 1226 = II. 625): $12^h\ 16^m\ 43^s$; $-\ 2°\ 40'·3$ from 2 obs. of h., with which H. also agrees nearly; but upon my chart I find no nebula drawn in this place.
Nova	12 16 58	+ 8 35·2	
2921	12 17 20	+ 8 5·0	
2926	12 17 47	+ 8 14·3	
2915	12 18 11	+ 5 41·6	The Æ in G. C. ought to be corrected by $+\ 1^m$, as indicated also by the note to h. 1228 (in Ph. Tr. 1833), which, however, should read: "nisi Æ = $12^h\ 16^m\ 37^s·5$," instead of 25·4, probably by mistake repeated from the preceding note.
5645	12 18 34	+ 1 20·9	Marth 239.
2970	12 19 13	+ 3 16·6	
Nova	12 19 23	+ 9 38·6	F, pL.
2969	12 19 24	+ 9 47·7	The Æ in G. C. is 10^s smaller, but the neb. is very large.
2971	12 19 26	+ 4 43·6	
2973	12 19 35	+ 9 12·8	
2975	12 19 38	+ 8 42·4	
2976	12 19 44	− 0 6·4	
2978	12 19 48	+ 3 16·1	
2980	12 20 0	− 5 2·8	
2986	12 20 18	+ 7 2·3	
2989	12 20 30	+ 8 55·7	
3873	14 17 33	− 12 32·3	
Nova	19 20 25	− 25 56·6	* 9^m att. f.
Nova	21 41 20	− 13 37·7	Very small, but not very faint; nearly south of a star 11^m. In the position of G. C. 6010 (Marth 454): $21^h\ 40^m\ 1^s$, $-\ 13°\ 53'$, I have no nebula drawn upon my chart.
4723	21 51 46	− 17 10·7	
4728	21 53 28	− 13 56·9	
4738	21 54 38	− 19 35·5	
4851	22 44 22	− 6 17·7	
6094	22 46 42	− 7 19·0	Marth 503.
6099	22 48 23	− 6 15·0	Marth 507.
Nova	22 54 9	− 7 6·5	vS, * 11^m n, close to it.

RECENT MEASURES OF DOUBLE STARS.

By C. E. BURTON.

The measures here given were obtained with a filar micrometer attached to a 12^{in}-reflector, equatorially mounted and provided with a Right Ascension movement of sufficient smoothness and steadiness to permit of sharp photographs of the Moon being taken with exposures amounting to 30 seconds.

(1) Sirius A & B 1874, Oct. 26, $6^h\ 30^m$ to 7^h local sid. time at Rodriguez.
$P = 57°·5$ mean of 4 measures, Epoch 1874·83.

Though the preceding result depends on a single set of measures (1 night) the circumstances were exceptionally favourable, the stars being nearly in the zenith, and the companion so brilliant that the measures were made and the micrometer read by daylight. B remained visible long after the increasing daylight had put out the star at 160° (? Lassell's *comes* at 120° and 60″, 1865).

Hall gives, P = 57°·9 Epoch 1874·23 } Flammarion,* p. 38.
Dunér „ „ 57·1 „ 1875·19 }

(2) γ Virginis. Epoch 1880·19.
P = 336°·7 D = 5″·3

Given merely for the sake of comparison with standard measures.

(3) Σ, 175 (Bird's double near Castor). Epoch 1880·20.
P = 331°·7 D = 0″·9 (unsatisfactory, but confirmed by the apparent separation of the disks.)

Possibly this pair is slowly opening, though in 1873 with the same instrument and power the apparent interval between the disks was sensibly the same as at the epoch above given.

(4) κ Leonis. Epoch 1880·24.
P = 355°·3 D = 3″·4 ± (mere guesses from difficulty of illuminating the field, and unsteadiness of image).
Image very unsteady.

(5) δ Cygni. Epoch 1880·65.
P = 328°·3 D = 1″·5 + 0″·1 (Companion beautifully seen; blue).
α Lyræ. A.B. measured on the same night.
P = 155°·8 D = 49″·7

(6) λ Cygni. Epoch (*a*) 1880·70; (*b*) 1880·74.
(*a*) P = 85°·9 D = 0″·7 } (Concluded from the apparent interval
(*b*) „ 83·6 „ 0·8 } between the disks.)

The sum of the diameters of the discs plus the interval between them was measured at the earlier epoch as 1″·5, which confirms the estimate of the distance made on each occasion with a power of 940 diameters (measured).

A, white; B, bluish. The movement is evident on comparing the above with results by other observers, thus :—

De	P = 92°·7	D = 0″·47	Epoch 1866·39	Σ,	P = 86°·3	D = 0″·70	Epoch 1871·75
Da	„ 92·5	„ 0·69	„ 1866·99	Ws	„ 88·5	„ 0·45	„ 1872·65
Du	„ 92·6	„ 0·60	„ 1869·68	De	„ 83·9	„ 0·45	„ 1876·71
„	„ 90·6	„ 0·68	„ 1871·20	Ha	„ 84·3	„ 0·74	„ 1876·80
De	„ 88·7	„ 0·60	„ 1871·41	Bt	„ 84·7	„ 0·75	„ 1880·72

Taken from Flammarion except the last. On the whole there would seem to be no decided change in the distance.

(7) Σ,2 = H, 1007. Epoch 1880·80.
P = 25°·1 D = 0″·7 or 0″·8 (est. from diameters of disks).

Very unsteady and difficult to measure in position.

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* Catalogue des Étoiles Doubles et Multiples en mouvement relatif certain.

Quadrant taken in accordance with former results, but the preceding star generally seemed the smaller (of the two close stars), possibly by reason of the state of the air. Movement apparently becoming more rapid as regards angle, but the distance has not varied much.

According to Flammarion the following are some observations of this pair:

Md	P = 61°·6	D = 0″·6	Epoch 1843·93	Du	P = 44°·8	D = 0″·72	Epoch 1869·78
Se	„ 51·4	„ 0·68	„ 1858·43	De	„ 44·6	„ 0·5	„ 1872·67
De	„ 47·4	„ 0·5	„ 1866·64	Σ_2	„ 43·8	„ 0·88	„ 1874·71

Showing the average movement in angle to have been about 0°·6 *per annum* for the period 1843–75, and nearly 3° *per annum* from 1874–80.

This pair would probably repay careful watching and measurement, as it may be near *periastron*.

In the preceding list the abbreviations of observers' names have been adopted from Flammarion.

Weather and other causes have hindered me from carrying out plans for a detailed examination and measurement of difficult double stars, and the fragment here given includes all the results which seemed worth giving.

A RECORD OF THE PROGRESS OF ASTRONOMY DURING THE YEAR 1880.

By THE EDITORS.

The following pages form a continuation of the record of astronomical progress in 1879, which was published by one of us in the "Proceedings of the Royal Dublin Society." Like its predecessor, this record does not pretend to be complete, but only to be a series of brief accounts of work done during the past year, chiefly intended to draw the reader's attention to what has been done in the various branches of Astronomy. In future we intend to prepare somewhat similar summaries at shorter intervals, particularly of papers and memoirs not published in widely-circulating astronomical journals, and therefore more liable to remain unknown to many of our readers.

1. *Spherical Astronomy.*

Vol. XLV. of the "Memoirs of the Royal Astronomical Society" contains a paper by Mr. Christie "On the systematic errors of the Greenwich North Polar Distances." The author discusses, by means of observations made from 1836 to 1879, the determination of the co-latitude from circumpolar stars and the corrections to the position of the ecliptic. He comes to the conclusion that a determination of refractions can only be made satisfactorily by comparison with southern observatories, and that there is no reason to make a change in Bessel's refractions, which satisfy the Greenwich observations down to Z. D. 80° as well as can be expected.* Dividing the observations of circumpolar stars into four periods, there is very little evidence in favour of a diminution of the refractions, and such as there is depends chiefly on the adoption of the law $a + b \sin z \cos^2 z$ for the R — D correction. Mr. Christie, however, finds the old law $a + b \sin z$ better supported. The results for latitude deduced from observations of the sun being divided into three periods show a majority of 2 to 1 in favour of Bessel's refraction. A comparison of the Greenwich Catalogues with the Cape (1860) and Melbourne (1870) Catalogues also show remarkable discordances when the diminished refractions are used. As to the secular variation of the obliquity of the ecliptic the Greenwich results seem to support Leverrier's theoretical value, and are in favour of the old formula for R — D rather than of the new.

The difficult question of mean refraction is treated in a paper by Mr. Stone in the "Monthly Notices" for April, in which the author to some extent maintains the necessity of his diminution of the mean refractions which he proposed in 1867. It is, however, not possible to give an abstract in a few lines of this paper, or of Mr. Christie's reply in the number for January last.

At the May meeting of the Royal Astronomical Society Mr. Downing read a paper on the possible ten-month period of variation in latitude, in which the Greenwich observations of Polaris for the ten years 1868–77 are discussed, with the object of determining both the magnitude and phase of this variation, assuming its period to be 306 days. The co-latitude is formed from the observations of each month and the following quantities determined: r, the distance between the pole of the axis of rotation and that of the axis of figure; θ, or the angle which the great circle joining these poles made with the meridian of Greenwich at the epoch 1872·0; and z, or the correction to the assumed co-latitude 38° 31′ 21″·90. The results are $r = 0''{\cdot}075 \pm 0''{\cdot}015$, $\theta = 205° \pm 6°$, and $z = -0''{\cdot}089 \pm 0''{\cdot}011$. The value of θ indicates that the apparent latitude of Greenwich was a maximum on the 12th October, 1872, which result agrees well with that found by C. A. F. Peters in 1842–43 at Pulkova. On the other hand, Nyrén has found discordant results from three series of Pulkova observations, and concludes that there is no constancy of magnitude or phase in the variation of apparent latitude.

In the "Astr. Nachr.," No. 2339, Dr. Pechüle develops formulæ for correcting observations of the sun with an annular micrometer for refraction. He considers the ring as distorted by refraction into an ellipse. This principle has, however, already in 1874 been applied to star observations by Dr. Schrader †; in the end the formulæ do not turn out to be more convenient than Bessel's.

Professor Bakhuyzen communicates in the "Vierteljahrsschrift" (XIV., 408) the results of a series of observations made at Leiden, in order to determine the variation of the personal error in transit observations, depending on the brightness of the star. Sometimes a circular diaphragm, sometimes a fine grating of copper-wire was employed to vary the apparent brightness, and three observers used alternately the eye-and-ear method and the chronograph. The two methods did not give appreciably different results, the variation for a change of 2·5 classes of magnitude being $0^{s}\cdot04$, in good accordance with the amount which for a similar decrease of magnitude had to be added to the results of the Leiden observations of Mr. Gill's Mars-stars to reduce them to the mean result from ten observatories. It deserves notice, however, that Mr. Gill found by comparing the results of his heliometer observations with those obtained with meridian instruments, that the eye-and-ear observations did not show any discordance with the heliometer results such as the chronographic ones did. No such difference between the two methods of taking transits was found in Leiden.

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* Beyond the limit of Zen. Dist. 82° corrections sensibly agreeing with those found by Mr. Main are required.

† See "Vierteljahrsschrift," X., p. 212.

Mr. D. P. Todd has in the "American Journal" for January, 1880, a paper on the determination of solar parallax by investigations of the velocity of light. From the experiments by Foucault, Cornu, and Michelson* he deduces the most probable velocity of light = 299920 kilometers. Supposing the coefficient in the light-equation to be = $498^{s}\cdot3$ (Delambre $493^{s}\cdot2$, Glasenapp $500^{s}\cdot8$) and combining this result with Professor Listing's value of the equatoreal radius of the earth, the solar parallax becomes $8''\cdot802$, while Struve's constant of aberration, combined with the velocity of light, gives $8''\cdot811$. In conclusion, Mr. Todd shows that if we combine the maximum value for the velocity of light with the maximum coefficient, and minimum velocity with minimum coefficient, π will lie between $8''\cdot78$ and $''8\cdot82$, while the aberration in like manner gives the limits $8''\cdot80$ and $8''\cdot82$.

Preparations for observing the transit of Venus in 1882 are being made everywhere. The Astronomer Royal, in a paper read before the R. Astronomical Society, remarks that the observation of this transit will be comparatively easy and inexpensive, owing to the facility with which the requirements for geographical position are satisfied, and the easy communication of time by telegraph. Greater importance is now attached to the elevation of the Sun than formerly. For the four principal phases (ingress accelerated and retarded, egress accelerated and retarded) it is proposed to rely mainly on: 1st, the Cape Colony; 2nd and 3rd, the shores of Canada and the United States, Bermuda, and the West Indian Islands; 4th, the eastern shore of Australia or of New Zealand, if telegraphic communications be made.

The volumes of the "American Ephemeris" for the years 1882 and 1883, published by Professor Newcomb, differ in many respects from the previous volumes. In the ephemeris for the meridian of Greenwich, the places of Venus are now given for every day, and those of Uranus and Neptune for every four days, also heliocentric co-ordinates for all the planets for every four days, and the Sun's co-ordinates for every day. The mean places of 383 stars are given, the circumpolar stars also being entered in the list at $\alpha + 12^h$. The apparent places are, however, only given for the 208 stars in the previous volumes, but a supplement is being prepared containing apparent places for the additional stars for the years 1881–83. Perhaps the most important innovation is, however, the introduction of diagrams of the apparent orbits of the satellites of the outer planets, which in the case of Saturn indicate where each satellite will be one, two, three . . . days after East Elongation. The usual diagrams of the configurations of the satellites of Jupiter, and tables of superior conjunctions of these and of elongations of the satellites of Saturn, Uranus, and Neptune add to the usefulness of this part of the volume.

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* Michelson's experiments were made with a revolving mirror like Foucault's, but his arrangements differed in many details from those of Foucault. The fixed mirror was plane, the focal length of the lens employed was 150 feet, and the revolving mirror was placed about 15 feet within the principal focus. The result is 299940 kilometers per second. Cornu's result was 299990 kilometers (No. 3 of the "Astron. papers prepared for the use of the American Ephemeris").

From the O'Gyalla Observatory are published " Klinkerfues'ische neue Constanten zur Reduction auf den scheinbaren Ort," computed for 1881 by Dr. Kobold from the data in the "Nautical Almanac." Calling the North Polar Distance of a star p and putting—

$$2\,k \sin \mathrm{K} = \mathrm{A} + \mathrm{D} \qquad\qquad 2\,l \cos \mathrm{L} = \mathrm{A} - \mathrm{D}$$
$$2\,k \cos \mathrm{K} = \mathrm{B} + 20{\cdot}0537\ \mathrm{C} \qquad\qquad 2\,l \sin \mathrm{L} = -\ \mathrm{B} + 20{\cdot}0537\ \mathrm{C}$$

the reductions to apparent place are—

$$\Delta\alpha = f + k \operatorname{cotang} \tfrac{1}{2}p \sin(\mathrm{K} + \alpha) + l \operatorname{tang} \tfrac{1}{2}p \cos(\mathrm{L} + \alpha)$$
$$\Delta\delta \sec \delta = i + k \operatorname{cotang} \tfrac{1}{2}p \cos(\mathrm{K} + \alpha) + l \operatorname{tang} \tfrac{1}{2}p \sin(\mathrm{L} + \alpha).$$

2. *Celestial Mechanics.*

No. 2 of the papers prepared for the " American Ephemeris " is entitled " A transformation of Hansen's lunar theory compared with the theory of Delaunay. By S. Newcomb aided by J. Meier." Owing to the peculiar form of the variables in which Hansen has expressed the co-ordinates of the Moon, his theory cannot be directly compared with that of Delaunay. Comparisons depending on data for the transformation given by Hansen himself, have already years ago been made both by Newcomb and by Schjellerup, but Professor Newcomb has now made a transformation which faithfully represents Hansen's latest theory, and is expressed in arguments depending directly on the time. In four tables are contained: I. Value of $n\delta z$ from Hansen, together with its powers; II. Principal parts of Hansen's ecliptic longitude with the coefficients of the concluded longitude; III. Reduced coefficients of longitude according to Hansen and Delaunay; IV. Expressions for latitude; and, V. Expressions for parallax according to Hansen and Delaunay.

At the visitation of the Royal Observatory, the Astronomer Royal stated that the computations relating to his own numerical lunar theory are considerably advanced and will, it is hoped, be finished ere long. While waiting for this part of the work, which is to give the correction to every coefficient of the ordinary lunar theory, the Astronomer Royal has been re-arranging the whole work for publication, and investigating special problems relating to the effect of the earth's oblateness, the effect of change of excentricity of the earth's orbit, the effect of change of position of the ecliptic plane, and the lunar acceleration (*see below*).

In the "American Journal" for January, 1880, Professor Stockwell has a paper on the inequalities in the Moon's motion produced by the oblateness of the Earth. The most important result is that the Moon's radius vector is subject to an inequality which affects the longitude by $+ 4''\cdot443 \sin \Omega$. Laplace finds, in a different way, $+ 7''\cdot03 \sin \Omega$, but Professor Stockwell shows that this arises from an oversight, and that after correcting this the two investigations yield identical results.

The "Monthly Notices" for May and June contain a paper by Messrs. Neison and Campbell, "On the determination of the solar parallax from the parallactic inequality of the motion of the Moon." The authors examine the results obtained by previous investigators, with a view to show why their results are discrepant. They next proceed to a fresh discussion of all the observations made at Greenwich between 1862 and 1876, determining the value of the parallactic inequality by the same method, and on the same assumptions as were formerly used by Professor Newcomb and Mr. Stone. Finding, however, thus practically the errors which had first been pointed out theoretically, the authors adopt a more extended method, in which they allow for all the errors likely to be in the tables, assuming that there may be errors due to other terms and other inequalities, and considering what their effect will be on the parallactic inequality. Their results now become very accordant and satisfactory. The solar parallax is found $= 8''\cdot848 \pm 0''\cdot007$. The authors, however, remark that a great objection to the method is the difficulty of clearing meridian observations of the Moon's limb from the variations in the irradiation depending on the darkness of the sky. They, therefore, propose to abandon the observation of the limb, and substitute a small sharply-marked crater near the centre of the nearer hemisphere of the Moon. They have selected the crater known as Murchison A, and the regular observation of this with ten or twelve clock-stars has been undertaken at Mr. Campbell's observatory at Arkley (Barnet, Herts).

As remarked by Mr. Stone ("Monthly Notices," November), the accuracy of the result of the above investigation depends on the assumed coefficients of the unknown quantity I, which the authors have used in correcting the semi-diameter of the Moon, from winter and summer observations, for the effects of irradiation. It is not stated how these coefficients were found to be approximately correct.

The important question, as to the correct value of the secular acceleration of the Moon's mean motion, has been discussed during the past year by the Astronomer Royal and Professor Adams in several papers in the "Monthly Notices," and the result has been a confirmation of the value for the coefficient first found by Professor Adams in 1853. After the publication of the two papers in Nos. 8 and 9 of the "Monthly Notices" no one can have any doubt as to the accuracy of the theoretical value of the coefficient; but still it would be interesting if anyone could succeed in pointing out the errors committed by Professor Stockwell in several papers, in which the old value is maintained against that of Adams and Delaunay. Another well-known difficulty is presented by the ancient eclipses, which hitherto at least have not agreed very well with the new value. It is, therefore, deserving of notice that Celoria derives the following results from an investigation of the celebrated eclipse of Agathocles.*

The theoretical value of the coefficient of the secular acceleration can be reconciled with the eclipse of Agathocles, either by correcting Hansen's motion of the lunar node by − 25″ per century after 1800, or by adopting a positive correction of from 0″ to 20″ to the motion of the node and *not* admitting that Agathocles sailed *south* of Sicily.

The lately issued Vol. XLV. of the "Memoirs of the R.A.S" contains a lengthy memoir by M. Souillart: "Théorie analytique des mouvements des satellites de Jupiter." The author proposes in this memoir to treat the theory of Jupiter's satellites by the variation of arbitrary constants, the memoir being a development of an earlier research by M. Souillart (" Annales de l'école normale supérieure, T. II., 1re série). Chap. I. contains the development of different perturbing functions; Chap. II. inequalities independent of excentricities and inclinations; Chap. III. inequalities depending on the excentricities; Chap. IV. inequalities depending on the higher powers of the perturbing force; Chap. V. inequalities in latitude; secular equations of longitude.

The "Philosophical Transactions for 1880," Part II. (pp. 713–891), contain Mr. G. H. Darwin's paper "On the secular changes in the elements of the orbit of a satellite revolving about a tidally distorted planet," the principal results of which very remarkable investigation may be supposed to be generally known, having been mentioned and reviewed in several places.† According to "Nature" (24th February, 1881) Mr. Darwin read a paper before the Royal Society on the 20th January, "On the tidal friction of a planet attended by several satellites, and on the evolution of the Solar System."

In the second part of this paper it is proved that the rate of expansion of the planetary orbits, due to the reaction of the frictional tides raised by the planets in the Sun, must be very slow compared with that due to the reaction of the tides raised by the Sun in the planets. The effect of tidal friction is to convert the rotational momentum of the tidally disturbed body into orbital momentum of the tide-raising body. Hence a numerical evaluation of the angular momentum of the various parts of the solar system will afford the means of forming some idea of the amount of change in the orbits of the several planets and satellites, which may have been produced by tidal friction. The result of this evaluation is, that the orbits of the planets round the Sun can hardly have undergone a sensible enlargement from the effects of tidal friction, since these bodies first attained a separate existence.

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* See his letter to Mr. Hind in the "Monthly Notices," January, 1881.

† "Monthly Notices," February, 1880, "Record for 1879," p. 7, "Astr. Nach." 2294, "Nature," "The Observatory," &c.

Turning to the several sub-systems, it appears, that although it is possible that the orbits of the satellites of Mars, Jupiter, and Saturn around their planets may have been considerably enlarged, yet it is certainly not possible to trace the satellites back to an origin almost in contact with the present surfaces of their planets, in the same manner as was done for the Moon in the previous papers. This can, however, not be regarded as unfavourable to the acceptance of the views concerning the Moon, as the numerical evaluation above referred to exhibits a marked contrast between the case of the Moon and that of the satellites of the other planets. It must be supposed that some important cause of change other than tidal friction has been concerned in the evolution of the solar system and the planetary sub-systems. Supposing this other cause to be the contraction of the heavenly bodies (in the nebular hypothesis), the author proceeds to consider the manner in which the two causes may have worked together. Of the results obtained we shall here only mention one. Supposing a satellite to be generated by contraction and increase of rotation of a planetary mass, tidal friction must diminish the rate of increase of rotation due to contraction, and therefore if tidal friction and contraction are at work together, the epochs of instability must recur more rarely than if contraction acted alone, and if the tidal retardation is sufficiently great, it may never permit an epoch of instability (*i.e.* the production of a satellite) to occur. The actual distribution of the satellites in the solar system seems thus explained, as the rate of solar tidal friction decreases rapidly as we recede from the Sun.

In the "Annales de l'Observatoire de Moscou," T. VI, Livraison II, Professor Bredichin has a paper on the resistance of the ether produced by the motion of translation of the solar system. The author develops the secular variations of the elements of a comet, first supposing that the resistance is proportional to the velocity, and afterwards on the supposition that it is proportional to the square of the velocity. He next develops the formulæ for the perturbing influence on the direction of the tail of a comet.

3. *The Sun.*

Early in the past year Mr. A. C. Ranyard's collection of "Observations made during total solar Eclipses" were published as Vol. XLI. of the Memoirs, R.A.S. (792 pp., 4to, with 18 plates). A work of this kind, embodying as it does, in systematically arranged chapters, a vast amount of observations, both published and unpublished, must always be welcomed with great pleasure. Scientific literature is now-a-days so extensive and, chiefly owing to the number of scientific societies all over the globe, in the publications of which authors can bury their investigations, so extremely difficult to master, that a compilation of the results, or even of all the material accumulated in any one branch of science, is a most useful piece of work. Of hitherto unpublished observations the volume contains a great many, chiefly from the eclipses of 1860, 1870, and 1871, the last one furnishing material for eleven of the plates. Particularly interesting are the eight plates representing the details of the structure of the Corona, visible in the photographs of 1871. We congratulate Mr. Ranyard on the completion of his useful undertaking.

The Washington Observatory has just published a Report on the Eclipses of 29th July, 1878, and 11th January, 1880, which volume has not yet reached us. We have, however, received two extracts from it, containing the observations by Mr. D. P. Todd and Professor O. Stone. We hope soon to give a full account of this interesting publication.

The Greenwich Spectroscopic and Photographic Results for 1878 and 1879 have been published in advance of the yearly volumes. The spectroscopic results consist principally of observations of solar prominences, and of determinations of motions of stars in the line of sight. In the photographic results the areas, distances from the Sun's centre, and position-angles are given for spots and faculæ, and the heliographic longitudes and latitudes for spots. The Photographs indicate that the minimum for spots and faculæ occurred about January, 1879. The rapid increase of solar activity in the last quarter of 1879 is very marked, and is accompanied by an increase in the mean distance from the Solar Equator, in accordance with the law found by Carrington at the minimum of 1855–56, and confirmed by Spörer's observations in 1867.* In 1878 the latitudes of spots ranged from 0° to 15°, and in the last four months of 1879 and the first four of 1880 from 12° to 35°.

Professor R. Wolf's "Astronomische Mittheilungen," No. 50, contains the statistics of sun-spots for 1879. The results combined with previous ones are—

	Sun Spots.	Magnet. Variation.
Minimum, . .	1867·2	1866·8
Maximum, . .	1870·6	1870·8
Minimum, . .	1878·9	1878·5

Professor Wolf believes that the late Mr. J. Allan Broun, if he had still been alive, would have become convinced of the continued accordance between the two phenomena. It is remarkable that the two minima of magnetic variation preceded those of sun-spots about 0·4 year.

The Philosophical Transactions for 1880, Part II., contain a paper by Mr. W. Ellis "On the relation between the diurnal range of magnetic declination and horizontal force, as observed at Greenwich, from 1841 to 1877, and the period of solar-spot frequency." The results of this investigation are, that the periods of magnetic and sun-spot effect are equal, and the epochs of maxima and minima nearly coïncident, the magnetic epochs on the whole occurring somewhat later than the corresponding sun-spot epochs. The occasional more sudden outbursts of magnetic and solar energy, extending sometimes over several months, appear to occur nearly simultaneously and progress collaterally.

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* See the "Record" for 1879, p. 9.

Professor Spörer has, from Professor Wolf's relative numbers, computed formulæ for the frequency of spots from 1752 to 1853 (A.N. 2335). The period, as computed from the epochs derived from the curves, is 11·328 years, and it appears that the maximum in 1870·8 was 1·0 year *before* the mean epoch, and the recent minimum in 1878·9, 0·5 year *after* the mean, the interval from maximum to minimum being 8·1 years, while the mean interval is 6·6 years.

Professor Spörer has published his observations of sun-spots from October 1871 to December 1873, in exactly the same form as his earlier observations (Potsdam Publications, Vol. I., No. 1). Special attention is called to a number of instances in which characteristic phenomena occurred. In about seventy cases out of a hundred a regular spot with a penumbra was formed in the *western* (preceding) part of a group. In cases of a penumbrated spot being divided into several spots, an arm of a facula is seen to be pushed in, *i.e.*, flaming prominences have spread in that direction. Thus the same explanation holds as for large groups which become crossed by bright streaks and where considerable flaming prominences have been repeatedly seen when the objects in question were known to be on the Sun's limb.

Professor Balfour Stewart has examined the sun-spot records from 1832 to 1867, with a view to ascertain to what extent these records exhibit indications of certain systematic inequalities, having periods differing but little from 24 days. He gives in Nature, XXII., p. 81, two tables exhibiting inequalities of respectively 24·022 and 24·329 days.

Amongst the spectra of sun-spots which have been examined at Greenwich, that of the fine spot, which was first seen near the east limb, on 25th November, appears to be quite unique; when examined on November 27 by Mr. Christie and Mr. Maunder, the most striking feature in the spectrum was a number of strong, dark lines as broad as b_1 or b_2, between b and F, to which there appeared to be nothing corresponding in the ordinary solar spectrum (at least not in Kirchhoff's and Ångström's maps). Under favourable circumstances, however, faint lines corresponding to most of them could be seen in the spectrum of the photosphere. They were not identified as belonging to any known element.

Mr. Lockyer (Proc. R.S., XXXI., pp. 72 and 348) has taken advantage of the recent activity in sun-spots to try whether the iron-lines in the spot-spectra showed any change of refrangibility indicating an "up-rush" or "down-rush." He found motion indicated by some lines, while other adjacent ones are in a state of absolute rest. Thus, in a spot on August 31, 1880, while the iron-line at 5207·6 was doubly contorted, indicating an ascending and descending velocity of about 15 miles a second, the two adjacent iron-lines at 5203·7 and 5201·6 were unaffected. In the fine spots visible on December 24, January 1 and 6, many iron-lines were seen contorted, while others were steady.

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OXFORD

4. *The Moon.*

The interesting but difficult problem of the physical libration of the Moon forms the subject of a memoir by Dr. E. Hartwig, of the Strassburg Observatory (Beitrag zur Bestimmung der physischen Libration des Mondes, Karlsruhe 1880, 51 pp. 4to). The author observed the crater Mösting A (the one observed by Wichmann in 1844–46) with the Strassburg heliometer from November 1877 to January 1879, during which period he obtained 42 measures. He had in 1876 commenced observing Manilius (the crater used by Bouvard and Nicollet), but thought it better to observe the same crater as Wichmann and Schlüter, so that his own results could afterwards be combined with an eventual new reduction of the old observations. Dr. Hartwig first gives a very full recapitulation of Wichmann's investigation of the influence of physical libration on the selenographical place of a point on the lunar surface, and then describes his measures and their reduction. According to Bessel's plan it was necessary to measure both the position angle and distance of the crater from seven points fairly uniformly distributed around the illuminated limb. Dr. Hartwig has not, however, adopted Bessel's plan of first making all the seven settings in one position of the two halves of the object-glass, and then in the reverse order the seven settings in the other position, but he preferred the more troublesome way of making the two settings for each of the seven points immediately one after the other. It is, no doubt, owing to this arrangement that his series of measures have produced results far more accordant *inter se* than those obtained at Königsberg. The objection of Mr. Neison to the heliometric method, that irregularities in the limb of the Moon must produce constant and periodic errors, is alluded to by Dr. Hartwig, who does not consider such errors likely to arise in this way. His results, as compared with Wichmann's, promise well for the exact solution of the problem, when the terms of long period shall have been determined by the reduction of Schlüter's and a revision of Wichmann's observations.

The measures of the lunar photographs taken at the Oxford University Observatory are now completely reduced, and a paper on the physical libration of the Moon is in course of preparation for the press.

In "The Observatory" (III., p. 373) Mr. H. Pratt has a very careful and critical paper on Klein's supposed new crater near Hyginus. By means of numerous observations, made by himself and Mr. Rand Capron, he shows how extremely doubtful the existence of this "crater" is, and how much more the observations tend to define it as a shallow depression, while the changing altitude of the Sun explains the discrepancies in the accounts.*

5. *Planets.*

Mercury.—The "Reports on telescopic observations of the transit of Mercury, May 5–6, 1878," which were distributed by the Washington Observatory in the beginning of last year, form a 4to volume of 126 pages. The separate reports of the astronomers of the Naval Observatory (including a joint report from Professors H. Draper and Holden) are first given in extenso; they include observations of contacts and of the diameter of Mercury. The disc of the planet did not seem very black, and no white spot or trace of an atmosphere was seen. Next follows a discussion by Prof. Eastman of the observations of contacts made by 109 observers throughout the United States. It appears that many observers attempted to observe the geometrical contact, but most of them failed to do so, in some cases owing to the appearance of a "black drop." On the other hand the observations of the rupture of the black drop at second contact, and its formation at third contact were easily observed and agreed well *inter se.* The second half of the work (60 pp.) is a discussion by Professor Paul of the phenomena attending the observations of contacts. In fifteen tables the various observations of the four contacts are exhibited, after which follows a most complete investigation of the phenomena of irradiation and their influence on the observation of the first and fourth contacts, and in the production of the "black drop."

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* Professor Winnecke also expresses himself to the same effect (V.J.S., XV., p. 151).

Venus.—M. Terby is preparing for publication a work on the topography of Venus to correspond with his "Aréographie." He has published ten drawings of Venus, made in 1871 and in 1873, on several of which some dark spots appear.[*]

Mars.—Mr. C. E. Burton's "Physical Observations of Mars, 1879–80," are published in the Transactions of the R. Dublin Society (Vol. I., No. 12) and include 24 drawings, two of which were made by Mr. Dreyer with the Dunsink refractor, while Mr. Burton employed an 8-inch and, occasionally, a 12-inch reflector, both made by himself and mounted at Loughlinstown, Co. Dublin. From these drawings a complete map of Mars, on Mercator's projection, has been constructed.[†] Many of the remarkable "canals" seen by Schiaparelli in 1877–78 were, independently, detected by Mr. Burton, chiefly between the meridians of 350° and 60° of areocentric longitude, and one of the Dunsink drawings of this region (made under exceptionally favourable circumstances) shows also distinctly several of the thin streaks or canals seen by Schiaparelli. Many of these have been identified by M. Terby on earlier drawings by Professor Holden and other observers, so that their existence can now hardly be doubted.[‡]

No. 2. of the Potsdam Publications contains physical observations of Mars in 1877 (twelve drawings), and reproduces in woodcuts eighteen drawings made by Galle in 1837, 1839, and 1847.

M. Terby has published synoptic tables of the various systems of nomenclature for the surface markings of Mars, which will, no doubt, be useful in preventing confusion (Bulletin de l'Acad. R. de Bruxelles, 2me. série, T. XLVIII., No. 12).

The Greenwich meridian observations of Mars made since 1851 have been examined by Mr. Downing, in order to find a value of the diameter of Mars which would agree better with the values derived from heliometer or wire-micrometer observations, than that found by Leverrier. Mr. Downing finds the diameter $= 9''{\cdot}697 \pm 0''{\cdot}107$, and the constant correction to the assumed value for irradiation $= 2''{\cdot}369 \pm 0''{\cdot}175$ ("Monthly Notices," Nov. 1880). Mr. Stone (M.N. January 1881) has compared all the results of the different observers at Greenwich with Leverrier's diameter ($11''{\cdot}10$), and with Mr. Downing's result. He shows how persistently the observed diameters differ from Mr. Downing's value, so that the results must be vitiated by some systematic error. It, therefore, appears essential that observations of single limbs of Mars should be reduced with values of the diameter determined by the same observer.

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[*] Bulletin de l'Académie Royale de Belgique, 2me Série, T. XLIX., No. 3 (March, 1880). This paper contains also observations of Mars and Jupiter made in 1879.

[†] This map will also appear in the new edition of Mr. Webb's "Celestial Objects."

[‡] Mémoires couronnés, &c., T. XXXI. (1880).

In November 1879 Prof. Young made a series of measures of the polar and equatoreal diameters of Mars with a wire-micrometer on the excellent 9·5-inch equatoreal at Princeton, N.J. The resulting ellipticity was $\frac{1}{219}$, the limits of probable error being $\frac{1}{156}$ and $\frac{1}{364}$. Prof. Adams found $\frac{1}{228}$ from the orbits of the satellites.

Jupiter continues to attract the attention of observers, on account of the interesting red spot in the southern hemisphere. Mr. Marth has, in the "Monthly Notices" (XL., p. 420), given a list of all the observed transits of this spot across the central meridian of Jupiter from July 1879 to February 1880. Dr. Julius Schmidt has discussed all the observations and deduced a period of rotation $= 9^h\ 55^m\ 34^s{\cdot}4$,[*] while Mr. Pratt has found $33^s{\cdot}9$ and Dr. Jedrzejewicz $34^s{\cdot}4$. From Athens observations in September and October 1880 Schmidt found $36^s{\cdot}89$. These results are about 9^s greater than the period found by Airy and Mädler in 1834–35, with which Schmidt's period found by observations of a dark spot in 1862, $9^h\ 55^m\ 25^s{\cdot}68$, was in good accordance. A large bright patch in the great southern belt was watched last autumn by Schmidt, Denning, and others, it revolved in about $9^h\ 50^m$, and has, consequently, a very rapid proper motion (M.N., XLI., p. 44).

Vol. I., No. 2, of the "Publicationen des astrophysicalischen Observatoriums zu Potsdam" contains physical observations of Jupiter and Mars by Dr. O. Lohse, partly made at Bothkamp. In 1872–73 a very dark streak on Jupiter in — 30° latitude was followed for 151 days; the resulting period of rotation was $9^h\ 55^m\ 19^s{\cdot}6$. The paper contains many other interesting observations and remarks on the satellites, their appearance, transits, &c., also attempts to determine their diameters (two observations in good accordance *inter se* give the diameter of Satellite III. $= 1''{\cdot}45$ at the mean distance, 5·2028).

Saturn.—In the Astr. Nachr., No. 2328, Mr. Marth as usual published ephemerides of the satellites of Saturn. In order to reconcile the observations of Mimas, made in 1879, with the Malta observations, and with those made by W. Herschel in 1789, the hypothesis of accelerated motion was adopted. Observations of this satellite are very much needed.

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[*] Astr. Nachr., 2342.

In March 1880 the Valz prize of the Paris Academy was given to Mr. Trouvelot for his descriptive designs of Mars, Jupiter, and Saturn.

Ultraneptunian Planets.—In a paper read before the Royal Society of Edinburgh,* Professor G. Forbes endeavours to find whether the aphelion distances of comets revolving in elliptic orbits indicate the existence of Ultraneptunian planets, which by their perturbing influence made the comets permanent members of the solar system. On tabulating all the aphelion-distances supposed to be known, it was found that the greater number of them seemed arranged in four groups, of which two nearly correspond to the mean distances of Jupiter and Neptune (5 and 30), while two other groups appear at the distances 100 and 300. Assuming that the comets of the two last groups were attracted into the solar system by two unknown planets, which revolve round the Sun at mean distances of 100 and 300, the Author considers two hypotheses. Either the disturbing planet moves in a plane inclined to the ecliptic and near which the majority of the aphelia under consideration lie, or the planet moves in an orbit, the plane of which is close to that of the ecliptic, and it attracted the comet when the latter was nearest to its orbit. Having examined the case of Neptune and its group, and having had to give up the first hypothesis in this case, the Author decides for the second one. The group at 100 he composes of—

Comet.		Period.	Aph. Dist.
1840	IV.	350	96·7
1843	I.	376	100·0
1846	VII.	400	108·2
1861	I.	415	110·3
1793	II.	422	111·0
1861	II.	419	111·2
1855	II.	493	124·2

Of these the third and the fifth one are, however, excluded, as the longitude and latitude of the aphelia do not agree with those of the other comets. Prof. Forbes now tries to find the present position of the planet, if it is supposed to be on the ecliptic and to have disturbed each comet at the time when it came nearest to the place of its aphelion. He deduces a motion of 1° in 2·96 years. The three comets 1843 I., 1861 II., and 1855 II., furnish three aphelion-dates, 1655, 1651, and 1609, and three longitudes of the planet, 98°, 97°, and 82°. The mean date, 1638, and the corresponding longitude 92° when combined with the motion of 1° in 2·96 years, determine the following place for 1880—

Long. 174°, RA $11^h 40^m$, NPD 87°.

This result can hardly be entitled to much weight, as it depends entirely on the aphelion-distances of four comets. Now, that of the comet I. 1843 is more than doubtful, and Donati's orbit of comet II. 1855, does not represent the observations very satisfactorily, while the period of comet I. 1861 is very uncertain.

Mr. D. P. Todd was already more than four years ago engaged in speculations on the existence of a planet exterior to the orbit of Neptune, and he has now published a preliminary account of his researches in the "American Journal" for September 1880. He treated the longitude-residuals of Uranus by a graphical method, similar to Sir John Herschel's "dynamical" exposition of the perturbations of Uranus arising from Neptune. Mr. Todd concluded that Uranus was in conjunction with an exterior perturbing body between the years 1780 and 1795, and that another conjunction would take place before the end of the present century. The most probable longitude is therefore 170° ± 10°, the most probable mean distance from the Sun being 52. The author next computed anew the position of the invariable plane of the solar system, and by a differential comparison of its inclination with the inclinations of the major planets found the inclination of the unknown planet = 1° 24′. Similarly the longitude of the node was found = 103°. On thirty clear moonless nights between November 1877 and March 1878 Mr. Todd was enabled to use the 26-inch Washington equatoreal in searching for the planet, which he considered it possible to detect among other stars of the 13th magnitude by its disk, which was expected to be 2″·1 in diameter. Many suspected objects were re-observed repeatedly, and the author considers it improbable that a planet of an apparent diameter of 2″ could have eluded his search.

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* An abstract of the paper appeared in "The Observatory," p. 439 & seq.

Minor planets.—Since the beginning of 1880, eight planets have been discovered, one by C. H. F. Peters, five by Palisa, one by Knorre, and one by Coggia. The latest found (220), which was discovered by Palisa on the 23rd of February last, may turn out to be identical with Juewa (139), found in 1874 by Watson, at Peking.

6. *Comets.*

Comet a, 1880.—On February 5, Dr. Gould of Cordoba, telegraphed to the late Professor Peters, at Kiel, that a great comet was passing the Sun northwards. On the following day he sent a second message, that the comet was moving southwards. Part of the tail had been seen at Cordoba on February 2, and the next night it appeared to have moved several degrees northwards, therefore the first telegram was sent. The head was first seen on Feb. 4, only 2° above the horizon. The tail was brightest on Feb. 7 or 8, when it was about 40° long. On February 20, the comet had completely disappeared. At the Cape the tail was seen already on Feb. 1 from the west side of Table Mountain, but though Mr. Gill obtained sketches of the tail on several evenings, he did not see the nucleus till Feb. 8. From very rough places from February 10 to 15, furnished by Mr. Gill, Dr. Copeland computed the elements of the orbit and pointed out their resemblance to the elements of the great comet of 1843 (Astr. Nachr. 2304). Dr. Gould had already on February 17 made the same remark (ibid. 2307). The orbit of the comet of 1843 was investigated by Hubbard, whose final result was an ellipse of 533 years, but though the sum of the squares of the residual errors was thus reduced to a minimum, Hubbard called special attention to the large changes in the major axis which might be made without doing violence to the observations. As remarked by Prof. Weiss (A.N.

2308), it is interesting, that Boguslawski suggested a period of 147⅓ years for the comet of 1843, and thought he could identify many earlier apparitions of the comet, the earliest being B.C. 371. Dr. Meyer has also called attention to an old orbit for the comet of 1843 by Plantamour, which with a period of only 21·8 years satisfies Clarke's sextant observation on Feb. 28, 1843, much better than Hubbard's orbit does (A.N. 2316). Simply to suppose, that the comet of 1843 has a period of 36·9 years is, however, difficult, as the question at once arises, why we do not possess accounts of the numerous earlier apparitions which could not fail to have been noticed, considering the size and brightness of the object. The comet of 1106 has been mentioned as one, to which a period of 36·9 years would bring us back, but as noticed in "Nature" (XXII., p. 18), the comet of 1106 was in the latter period of its visibility situated in the North West with a tail pointing to the North East, while the comet of 1843 did not remain north of the Ecliptic more than a couple of hours.

In a small pamphlet "Ueber die Kometen Erscheinungen von 371 v. Chr., 1668, 1843 I. and 1880 I." Professor Klinkerfues has arrived at important results concerning the great southern comet. He shows that the latter approached the surface of the Sun as near as 26700 geographical miles (of which $15 = 1°$ of the Earth's equator), while solar prominences often reach a height of 60000 geogr. miles. As the velocity in the perihelion is very great (72·07 g. m.), a very strong resistance from the solar atmosphere must be expected. According to Henderson the elements of the comet of 1843 satisfy the observations of the comet of 1668 within a degree. Supposing the two comets to be identical, the reduction of the period of revolution from 175 to 37 years can be explained if we suppose the velocity in the perihelion each time to have been decreased by 0·060847 geogr. mile. If q be $= 0·00601009$ or 119270 geogr. miles, such an amount of resistance would, however, if we go back beyond 1668 lead us to a hyberbolic orbit, but if q is decreased only 11·2 geogr. miles, we get a period of 2039 years and are brought back to the comet of B.C. 371. According to Aristoteles this comet was seen when Aristæus was Archon in Athens, at the time of the heliacal setting of the vernal equinox; it appeared at a time of severe cold.* It was first seen setting immediately after the Sun, the tail was long and narrow. The comet moved as far as Orion's belt, where it vanished. The heliacal setting of the equinox took place on March 2, therefore the perihelion passage probably took place on March 1, 16^h±M. T. Berlin. Carrying the elements of comet I. 1880 back to B. C. 371, Professor Klinkerfues finds that the comet on March 2 was barely 3° from the Sun, and if it be supposed to have been visible for as long a time as in 1843, the tail would reach Orion's belt before disappearing. In 17 or 18 years hence the comet ought to return, if it has met with the same amount of resistance in 1880 as formerly.

* This has made Pingré suppose that the comet appeared in mid-winter, but at Stagira in Thracia it may very well have been extremely cold on March 2.

In this connexion it may also be mentioned that Oppolzer (A.N. 2319) has tried whether Encke's formula for the resistance of the Ether can remove the difficulty about the period of revolution of the comet of 1843, but from formulæ in which the product of the resisting force by $1 - e$ is neglected it appears that with the value of $\frac{1}{880}$ for Encke's force U the influence of the resisting ether during the period of observation in 1843 is almost insensible. This is hardly to be wondered at, but the resisting power of the solar envelope must of course be immensely greater than that of "Encke's medium."

Comet b, 1880 was discovered by Mr. Schäberle at Ann Arbor at 11 P.M. on April 6. It was rather faint but had a tail about 3′ long. It passed the perihelion on July 1, and was again observed in the autumn for several weeks.

Comet c, 1880 or Faye's periodical comet was first seen by Mr. Common with his 3-feet reflector on August 2. It was extremely faint. Professor Axel Möller's ephemeris was as usual in excellent accordance with the observations and the R. Astronomical Society has justly awarded its gold medal to the indefatigable investigator of the orbit of this comet.

Comet d, 1880 was discovered by Hartwig on September 29 ; it had passed the perihelion on September 6, and its bright nucleus and long tail decreased rapidly in brightness. In a circular from the Strassburg Observatory, Professor Winnecke mentioned that there was a similarity between its track and that of the comet of 1506. The latter was seen both in Europe and in China, but the observations are very poor. Supposing the perihelion-passage to have taken place on July 1, 1506 (old style) and using the elements of comet *d*, 1880, Dr. Hartwig found a track in fairly good accordance with the one indicated in the Chinese annals and the European chronicles. In a second circular Professor Winnecke stated that a further examination of the records of the comets of 1382, 1444, and 1569, had also led him to suppose these to be identical with Hartwig's comet. Drs. Schur and Hartwig worked out a set of elements from the observations of Sept. 29, Oct. 14 and 24, assuming a period of 62⅓ years, but the error of the middle place was considerable (28″ in both co-ordinates) and could not be diminished. Messrs. Schulhof and Bossert have from six normal places (founded on observations taken at twelve observatories between Sept. 30 and Nov. 29) found an ellipse with a period of 1280 years.

Comet e, 1880 was discovered by Lewis Swift on October 11, but on account of bad weather it was scarcely observed in Europe until detected independently at Dun Echt on November 7 by Mr. J. G. Lohse. As soon as the elements of its orbit were computed, their resemblance to those of comet III., 1869 was noticed. The orbit has been thoroughly investigated by Messrs. Schulhof and Bossert (Comptes Rendus, Dec. 6 and 13), Mr. Chandler (A.N. 2355), Prof. Frisby (ibid. 2359), and Mr. Winslow Upton (ibid. 2363) and all these investigations assign a period of 5½ years to the comet.

Comet f, 1880 was found by Dr. Pechüle at Copenhagen, on December 16, as a small, rather bright object, which, however, rapidly became fainter. It had already passed the perihelion on November 9.

An object was found by Mr. Swift, on August 11, about 1° from the nebula I., 262. Clouds came on before any motion could be detected, and the object has not since been seen.

Winnecke's periodical comet was in perihelion on December 4, and an ephemeris had been published by Dr. v. Oppolzer, but the track of the comet was too unfavourable for observation. From his calculations of the apparitions of 1858, 1869, and 1875, Oppolzer found that a satisfactory accordance is impossible, without either diminishing the mass of Jupiter to $\frac{1}{1051}$ (which is impossible according to all modern determinations) or assuming an acceleration due to the influence of the resisting medium. The value found for Encke's force U is $\frac{1}{891}$ (A.N. 2319), agreeing well with Encke's result. Oppolzer points out, that with this value, the effect on Faye's comet will be so small as to disappear in the uncertainty of the perturbations. Nothing can be made out regarding the *form* of the resisting force.

7. *Meteors.*

A meteorite supposed to weigh about 120 lbs. has been found on the Tvanpah, California. Without etching the Widmannstätten figures are seen in the fragments. An analysis by Prof. Shepard has revealed 94·98 per cent. iron and 4·52 per cent. nickel.

An account is given in the "American Journal" of a shower of meteorites which fell at Eitherville, Iowa, on May 10, 1879. Fragments obtained weighed 437, 170, 92½, 28, 10½, 4, and 2 lbs. In 1880, when the grass of the prairies was burnt away, probably 5000 pieces were found from the size of a pea to a pound in weight.

Professor Silvestria of Catania states that a shower of meteoric dust mingled with rain fell on the night of March 29, 1880. There was a considerable proportion of iron in the dust, both in a purely metallic state and in metallic particles coated with oxide. The size varied from a tenth to a hundredth part of a millimeter, and the form was either irregular or spherical as if it had undergone fusion ("Nature," XXI., p. 574).

8. *Fixed Stars.*

A most important work by Mr. Lewis Boss, now Director of the Albany Observatory, "Declinations of Fixed Stars," was published last year by the U.S. Northern Boundary Commission. Originally the declinations deduced in this memoir were only intended for the use of the Boundary Commission, but in the course of his researches Mr. Boss was led to extend his plan, until the present work was produced, which contains a most thorough discussion of systematic corrections to the declinations of nearly all catalogues, as also a catalogue of the declinations for 1875·0 of 500 stars in both hemispheres. Mr. Boss' system of declinations is remarkable in not being founded on Bradley, the Author assuming that the systems of Bessel (1821), Struve (1824), and Argelander (Åbo, 1830) are sufficient in connexion with recent determinations to enable us to deduce a reliable system of corrections to the various catalogues.

The Engineer Department, U.S. Army, has published a catalogue of the mean declinations of 2018 stars from 0^h to 2^h and 12^h to 24^h of R.A., and + 10° to + 70° Declination, prepared by Prof. Safford. The stars are situated in the hours of R.A. most suitable for observations in connexion with the U.S. Geographical Surveys. In the preparation of this work all modern catalogues and Dr. Auwers' new reduction of Bradley have been used. For proper motions in R.A. Mädler's values have been employed, while the proper motions in declination have been determined by comparing older observations with modern ones.

Vol. XII. of the Annals of the Harvard College Observatory contains the meridian observations, made in 1874-75 by Prof. W. A. Rogers, of the fundamental stars of the Astronomische Gesellschaft; the same stars as had already been observed in 1871-72, and the results published in Vol. X. of the Annals. A few changes had been made in the plans, thus two observations of declination were made during each meridian passage by taking transits over oblique wires. For stars observed by Bradley the proper motions were found by a comparison of the places for 1755, furnished by Auwers, and the observed places for the approximate epoch 1865. For stars not observed by Bradley a comparison was made between normal places for 1830 and 1865, deduced from various authorities.

At the December meeting of the R. Astronomical Society Dr. B. A. Gould made a most interesting verbal statement on his zone observations in the southern hemisphere.* These zones extend from 80° to 23° south declination; they were commenced in September 1872 and finished about the middle of 1875, at which time about 76 zones and 106,000 stars had been observed. The zones were of varying widths, beginning with zones 2° broad (with half the width as the milky way was approached), and they continued increasing slightly in breadth until they reached the southern limit, but always subject to the restriction that in approaching the milky way they were made sufficiently narrow. All the instrumental constants were determined before and after each zone. Every star was observed on one group of wires and with one microscope. The reductions are far advanced.

"Über die Parallaxe von α Centauri" is the title of a most thorough investigation by Dr. W. E. Elkin, now Mr. Gill's assistant at the Cape of Good Hope (Karlsruhe, 1880, 44 pp., 4to). On account of the possible existence of errors in the hitherto deduced parallaxes for α and β Centauri, arising from periodical errors in the observations, the Author undertook to determine the relative parallax of these two stars, which can be found with far greater certainty than the absolute parallaxes. A considerable part of the paper is taken up by an investigation of the orbital motion of the two components of α Centauri, and of the proper motion of their centre of gravity. Whether the latter differs at all from the middle point between them is left undecided. From observations of the three stars by Maclear on 95 days Dr. Elkin finds the relative parallaxes—

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* "The Observatory," Vol. IV., p. 4; "The Astron. Register," Vol. XIX., p. 5.

$$\begin{aligned}\text{Of } \alpha_1 &= 0''{\cdot}6014 \pm 0''{\cdot}0813\\ \text{Of } \alpha_2 &= 0''{\cdot}4234 \pm 0''{\cdot}0899,\end{aligned}$$

the mean of which is $0''{\cdot}5124$. Dr. Moesta's observations of α_2 and β give a relative parallax of $0''{\cdot}3692 \pm 0{\cdot}0760$, which result, however, appears less certain and more likely to be influenced by periodical changes of temperature. Dr. Moesta has since in the Astron. Nachr., Nos. 2349, 55, 56, discussed his observations anew and found $0''{\cdot}521$ for the absolute parallax of α_2, and $0''{\cdot}348$ for the relative parallax, and a correction of $+ 0''{\cdot}7$ to the constant of aberration. As some considerable part of the very large value for the absolute parallax of α Centauri is, possibly, due to the influence of temperature, a renewed determination of this parallax is very much needed.

Dr. Ball has again determined the parallax of 61 Cygni by a series of measures of the difference between the declination of the following component and the same star of the 9·10 magn. north following which he had employed in his former series of measures of the preceding component. The observations were made between September 18, 1878 and October 2, 1879, and the resulting parallax was $0''{\cdot}4676 \pm 0''{\cdot}0321$, agreeing very closely with the result of the former series ($0''{\cdot}4654$).[*]

The investigation by the same Author of the parallax of the star Groombridge 1618, the result of which was $\pi = 0''{\cdot}33$, is published above (p. 16 & seq.).

Dr. C. H. F. Peters calls attention to the two stars B.W. 12^h, 69 and 124, which have considerable proper motions. From all available sources he finds for 1860·0 (Astr. Nachr. 2299)—

$12^h\ 5^m\ 23^s{\cdot}99 - 0^s{\cdot}037t$	$-2^\circ\ 19'\ 17''{\cdot}9 + 0''{\cdot}38t$
$12\ \ 8\ \ 57{\cdot}76 - 0{\cdot}071t$	$-2\ \ 14\ \ 2{\cdot}0 - 0{\cdot}17t$

A very interesting variable star of the Algol type was discovered by Ceraski at Moscow on June 23. It is the star D.M. + 81°, No. 25, observed four times by Schwerd in 1827–28, whose observations distinctly show the variability. The period was first by Schmidt announced to be $4^d\ 23^h{\cdot}6$, but when two minima had been observed at the Harvard College Observatory on September 23 and 28, Professor Pickering came to the conclusion that the period was only half as long or two days and a half (Dun Echt circular No. 10), to which result Schmidt had also in the mean time come. After observing fourteen minima, Schmidt has found that each period is $5^s{\cdot}25$ longer than the previous one.

Attention is drawn in "Nature"[†] to a number of stars about the magnitudes of which the various catalogues differ more or less, and, which, therefore, should be watched for variability. Dr. C. H. F. Peters gives in the Astr. Nachr., No. 2360, various details about fifteen stars for which his observations during the course of years indicate variability.

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[*] Monthly Notices, XLI., p. 162.

[†] XXII., pp. 76 and 348, XXIII., p. 206.

Dr. Dunér has noticed the star B.D. + 37°, 2771 to be variable between 8·3 and 12 mag.; the period is about 290 days. The red star Schj. 57*a* is also variable (A.N. 2329 and 2364).

9. *Double Stars.*

M. Otto Struve has published a memoir entitled "Etudes sur le mouvement relatif des deux étoiles du système de 61 Cygni."*

In 1852 W. Struve stated that the uniform and rectilinear motion deduced from his recent measures satisfied all the relative positions determined during a century. In 1875 Mr. J. M. Wilson investigated all known measures of this star, and found that the hypothesis of uniform, rectilinear motion satisfied the observations of position angle, made during this century, sufficiently; but that it made the computed distances a little smaller than the observed ones during the last 25 years; the hypothesis also failed to fairly satisfy the observations of last century (M.N. XXXV). The subject has now been investigated by M. Struve, who first discusses all the observations made at Dorpat and Pulkova from 1828 to 1874. These observations could conveniently be arranged in four groups, and the arithmetical means of the epochs in these groups being accidentally nearly fourteen years apart, advantage was taken of this circumstance to reduce all the measures to the beginning of the years 1835, 1849, 1863, and 1877, for which dates the relative rectangular co-ordinates resulting from each night's measures are given. The differences between the successive means are—

	dA		*dD′*	
1835·0 – 1849·0	+ 0″·821	± 0″·024	– 2″·625	± 0″·025
1849·0 – 1863·0	0·517	0·047	2·590	0·037
1863·0 – 1877·0	0·412	0·054	2·620	0·038

As the motion in R.A. is diminishing, while that in declination is constant, the relative motion cannot be regarded as taking place uniformly in a straight line. The number of observations in the third group being small, the second and third groups are amalgamated, and the original observations reduced a second time to the epochs, the terms multiplied by t^2 being taken into account. This produced but very slight changes in the mean values. From the three pairs of relative co-ordinates for 1835·0, 1856·0, and 1877·0, a circular, excentric orbit for the satellite is now deduced under the supposition that the excentric anomalies vary proportionally with the time. The distance of the primary from the centre is 19″·694, the position angle being 232° 21′, and the radius of the circle 33″·445. The comparison of all the observations with this orbit shows a fairly satisfactory agreement. The earlier observations (from the time of Chr. Mayer) are also compared after having been corrected for personal errors in accordance with Vol. IX. of the Pulkova Observations. On the whole, the orbit represents the observations well.

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* Mém. de l'Acad. de St. Pétersbourg, T. XXVII., No. 11 (38 pp.).

The question as to how the great number of erroneous measures in the late Admiral Smyth's "Cycle" are to be explained, has at last been solved in a paper by Mr. E. B. Knobel (M.N. June), containing notes on a series of observations by Mr. Burnham, of 150 of the objects in the Cycle, mostly distant pairs. Mr. Knobel first shows by quotations from the Cycle, and from Smyth's original MS, that Smyth himself attached little or no weight to the 148 objects to which he gave "Weight 1", as they were nothing but rough estimations, often assisted by the difference of R.A. being taken by transits over a vertical bar fixed in the field for this purpose. Mr. Knobel next considers the position angles (of which 96 have weight 1). These were generally taken by means of a "spherical chrystal micrometer," now in the possession of the Astronomer Royal, and the way the readings of this instrument were reduced to position angles, furnished a fruitful source of errors.

In nf and sf quadrants	In np and sp quadrants
Pos. ang. $= 360^\circ -$ reading	Pos. ang. $= 360^\circ -$ reading
or $= 180^\circ -$ reading	or $= 180^\circ + (360^\circ -$ reading).

If Smyth's figures had not been mistaken for carefully made measures, the numerous errors in them would never have created so much surprise.

In the American Journal for June last, Prof. Hall has a note on the companion of Sirius. He considers that the period will prove to be decidedly greater than what the disturbed motion of Sirius calls for. We are now approaching a critical time, and a few years of careful observation will go far towards deciding the question of identity with Auwers' perturbing body.

In several notes in the Astr. Nachrichten, Mr. Burnham calls attention to interesting close double stars. Thus, in 1878 he found 85 Pegasi to have a second very small companion $0''{\cdot}7$ distant, which already is clearly proved to be physically connected with the bright star. ζ Sagittarii was discovered to be double by Winlock twenty years ago, but seems only to have been measured once in 1867, by Newcomb. Recent measures indicate rapid motion. Last summer Mr. Burnham found that κ Pegasi is a very close double star, the components being nearly equal (Pos. 138° Dist. $0''{\cdot}2$). It is a good test for the defining power of a telescope.

Mr. Burnham's eleventh catalogue of new double stars forms part of his "Report to the Trustees of the James Lick Trust of Observations made on Mt. Hamilton, with reference to the location of Lick Observatory" (Chicago 1880, 32 pp. imp. 8vo). With his 6-inch refractor, Mr. Burnham was able to discover forty-two mostly very difficult objects, some of which, on account of their great south declination, are quite out of the reach of European or American observers; but which, at Mt. Hamilton, could be observed and measured within a few degrees of the horizon. This eleventh catalogue raises the number of new objects found by Mr. Burnham to 775. The report also contains measures of 90 other double stars, and bears testimony to the excellence of the selected site, as regards steadiness and transparency of the air, and the general prevalence of clear weather.

In the American Journal for June last, Professor Holden points out what seems to be a real relation between the colours and magnitudes of the components of binary stars. From two tables prepared by Mr. Burnham it is seen that the components of the 122 binary stars of the same colour differ in magnitude only $0^{m}{\cdot}5$, while the components of 40 binaries of different colours differ in magnitude on the average $2^{m}{\cdot}4$.

It would be unbecoming to leave the subject of double stars without referring to the great loss this branch of Astronomy has sustained through the death of Baron Dembowski. Since the year 1852 this patient and indefatigable observer had occupied himself in re-measuring the objects in the Dorpat and Pulkova catalogues of double stars, and the superior quality of his results was acknowledged by M. Otto Struve, in a paper in the "Vierteljahrschrift der Astr. Gesellschaft" (VIII., p. 100), and by the R. Astron. Society, whose Gold Medal was conferred on Baron Dembowski, in February 1878. Many people think the measurement of. double stars a mere trade which can be learned in no time, but that Baron Dembowski must be considered an artist in the field he had selected, will be universally acknowledged.

10. *Nebulæ.*

Part III. of the "Observations of Nebulæ and Clusters of Stars made at Birr Castle from 1848 to 1878," containing the last ten hours of R.A., was published last summer, and concludes the series (Trans. R. Dublin Soc., Vol. II., 42 pp. and two plates). This publication embodies all the work done on nebulæ since the erection of Lord Rosse's six-foot telescope in 1845. Of late years there was not much to be done with the pencil, as all the more interesting objects had already been drawn ; but a considerable number of micrometric measures were taken of groups of nebulæ or of nebulæ and neighbouring stars, and special pains were taken to identify all the *novæ* which were found in the course of years.

The systematic search for planetary nebulæ instituted by Professor Pickering has led to the discovery of three new objects of this class. They were found by sweeping with a direct vision prism inserted between the eye-piece and the object-glass of the 15-inch refractor at the Harvard College Observatory. The places of these objects are for 1880—

18^{h}	4^{m}	19^{s}	-28°	$12'$
18	14	23	-26	53
18	25	10	-25	13

It has already been mentioned above (p. 2), that Dr. Copeland found a similar object by adopting this method of searching. The object is, however, not new, but was found by Mr. Burnham, in 1873 (Mem. R.A.S., XLIV., p. 216).

In the "Comptes Rendus" for April 12, 1880, M. Stephan gives the micrometrically determined places of forty new nebulæ.

M. Tempel has in the Astr. Nachr., No. 2347, published places and descriptions of twelve nebulæ not previously announced.

Professor Winnecke remarks (A.N. 2293) that the nebula *h*882 = I. 20 appears to be periodically variable as regards its brightness. W. Herschel in 1785 called it very bright, J. Herschel in 1830 and 1831 very faint or faint, Boguslawski (about 1840), seems to have seen it with a 3½-inch refractor, as he has entered it as bright on Hora XII of the Berlin maps. In 1856, and again in 1878 and 1879, Winnecke called it pretty bright, while d'Arrest in 1863 termed it "subobscura."

Mr. Baxendell has noticed a very large but faint nebula north of the fine cluster M. 2 (G.C. 4678). It is said to resemble the Merope-nebula, but to be slightly fainter (M.N. Nov. 1880.)

Three different drawings of the nebula at Merope, by Mr. Maxwell Hall, Mr. Common, and M. Tempel, have been published in the Monthly Notices, Vol. XL. The first and the third one agree remarkably well. Mr. Common has also seen two small detached nebulæ, one north of Merope, and one np Alcyone.

Mr. Arthur Searle states (A.N. 2358) that during the last five years he has become convinced that a very faint but permanent band of light extends from Aquila to the Pleiades, passing through Aquarius and the southern part of Pisces and Aries. From its position near the ecliptic it may interfere with observations of the zodiacal light.

Professor Henry Draper has succeeded in photographing the brighter part of the great nebula in Orion with an exposure of 51 minutes, employing a triple objective of 11 inches aperture by Clark, corrected specially for chemical rays.*

11. *Photometry.*

This hitherto much neglected branch of Astronomy is being vigorously investigated at the Harvard College Observatory. In Vol. XI., Part 1, of the Annals (issued in 1879) Prof. Pickering gave detailed descriptions of his photometers, and discussed comparative observations of planets and photometric measures of the more conspicuous double stars. Vol. XI., Part 2 of the Annals and the lately issued annual report to the visiting committee of the observatory bear testimony to the great energy and talent with which these researches are being continued.

The satellites of Mars were observed photometrically, both in 1877 and in 1879. The light of each satellite was compared with that received from a small portion of Mars through a hole $\frac{1}{100}$ of a millimeter in diameter. These measures appear to show that, if we assume the satellites to have a capacity for reflecting sunlight equal to that of Mars, Deimos has a diameter of about six, and Phobos of about seven miles. Deimos seemed brighter in 1879 than in 1877, and in both years it was more easily seen when it followed than when it preceded Mars.

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* We learn from Professor Draper that he has recently obtained a photograph of the nebula in Orion with an exposure of 140 minutes, on which stars down to the 14th mag. are shown.

The observations of the satellites of Jupiter have resulted in the following equivalent diameters for these bodies: 0″·87, 0″·82, 1″·04, and 0″·62, while the measured diameters are 1″·08, 0″·91, 1″·54, and 1″·28. No variability has been perceived. Photometric observations of the eclipses of the satellites were commenced in 1878, and have been regularly continued. The results thus far obtained confirm the hope with which the work was undertaken—that it would lead to a more precise knowledge of the times of the eclipses than had formerly been attainable. Two eclipses of satellite I. have been compared by plotting the observations of each, and drawing smooth curves through them. The respective intervals in seconds, from the computed time of the eclipse, at which the satellite had diminished in brightness 1·5, 2·0, 2·5, 3·0, and 3·5 magnitudes, were in the first case + 33, + 16, + 4, − 6, − 13; in the second case + 40, + 18, + 6, − 2, − 9. Regarding these as two sets, each consisting of five independent and equally precise observations, it was found that they indicate a change of $3^{s}{\cdot}8$, with a probable error of $0^{s}{\cdot}6$. It is hoped that in the final reduction, in which proper weight will be assigned to each observation, the time of an eclipse will be determined with a probable error of less than a second, while M. Glasenapp has found the probable error of observations of the customary kind to be between nine and ten seconds.

Photometric measures of the eight satellites of Saturn were made in 1877 and 1878, particular attention being given to the variability of Japetus. The two outer satellites of Uranus, the satellite of Neptune, and a few of the minor planets were also observed, and their equivalent diameters deduced. Some of the minor planets do not seem to be much larger than the satellites of Mars.

A new photometer has been constructed by Prof. Pickering for the comparison of stars moderately near each other, but too distant to be brought into the same field by any of the photometers already in use. The polarized images of the two stars are brought to equality by turning a Nicol prism, and both images are seen under the same conditions. The range of positions in which the double-image prism may be placed is greater in this than in previous photometers made on the same general principle. The instrument is being used for comparing β and ω Persei, for which purpose it is not used in connexion with the 15-inch refractor, but as a separate instrument, furnished with a small object-glass. The results of these comparisons are in the annual report stated to be remarkably accordant, and to promise a determination of the light curve of β Persei with increased precision.

Considerable progress has been made with another series of photometric observations, viz., the determination of the light of all the stars visible to the naked eye at Cambridge (Mass.). As most of these stars would be troublesome to identify in the field of a photometer mounted on an ordinary stand, they are observed in the meridian. The photometer consists of a horizontal telescope pointing to the west and having two object-glasses. By means of two prisms mounted in front of the telescope the pole star is reflected into one object-glass and the star to be measured into the other. The images are brought to equality by turning a Nicol prism inserted in the eye-piece. The two stars are thus viewed under precisely the same conditions, with the same power and aperture, on the same background. The observer remains in comparative darkness and has an assistant to read off the circles and write down the results. The zones were commenced in October 1879, and it is hoped that the observations will be completed next autumn. Each star is to be observed on three different nights by different observers, and four settings are made each night. To determine the atmospheric absorption, a hundred circumpolar stars are observed at both culminations.

A highly interesting paper: "Dimensions of the Fixed Stars with especial reference to Binaries and Variables of the Algol type," is published by Professor Pickering in the Proceedings of the American Academy, Vol. XVI. (37 pp.). As direct measurements cannot be made of the discs of the fixed stars the author tries to deduce some information with regard to their dimensions from the amount and character of their light as he had already done in the cases of satellites and minor planets. For stars which have a spectrum similar to that of the Sun, it is assumed that the intrinsic brightness is the same as that of the Sun. The equivalent diameters (in seconds of arc) of stars from magnitude 0 to 14 are determined, taking the magnitude of Sirius as — 1·5 and that of the Sun — 25·5 When the parallax of a star is known, its linear diameter may be found. Thus, adopting $0''\cdot9$ as the parallax of α Centauri, the diameters of the two components are 1·82 and 0·46 times that of the Sun, while the latter will appear as a star of 1·3 magnitude when seen from α Centauri. In the case of a binary star, Kepler's third law will give us the diameter of a star having the same mass as the binary and the same density and intrinsic brightness as the Sun, expressed in terms of the period and the semiaxis major. The relative masses of the two components could be determined by measuring the positions and distances of each component from adjacent stars. The author has put together in a table the places, elements, and magnitudes of 33 binary stars and calculated the magnitude of a star having the mass of the binary and the density and intrinsic brightness of the Sun, and the magnitude of a star having the mass of the binary and the brightness of its components. The differences between these quantities are rather large, and as they almost all have the same sign, it is inferred that the assumed light of the Sun is too small. A great part of the difference must be ascribed to variations in the density or brightness of the stars. Until we have means of determining the intrinsic brightness of a star it is considered convenient to reduce this difference from magnitudes to the relative diameters of two stars of equal density and brightness, one having a mass, the other emitting a light equal to that of the binary. Assuming the diameter of the first of these stars as a unit, the diameter of the other is in almost all cases found to be greater than unity, and the author concludes from this that most of the stars enumerated are either much brighter or much less dense than the Sun, unless the measurements of the light of the Sun are largely in error.

In the second part of the paper, Professor Pickering examines the hypothesis that the variability of stars of the Algol type is due to a non-luminous body which revolves round the star. From Schönfeld's light-curves for Algol it is found that the eclipse must be a partial one, caused by a body the radius of which is limited between infinity and 0·764 of the radius of Algol. On calculating the light of the uneclipsed portion for every half-hour from minimum with several values of the radius, it appears that the value $r = 0{\cdot}764$ best satisfies the observations. The orbit is investigated and a circular orbit with a diameter = 0″·028 (the diameter of Algol being assumed = 0″·06) and an inclination of 87° is found to satisfy the observations extremely well.*

12. *Spectroscopy.*

In Dec. 1879 Dr. Huggins read a paper before the Royal Society, published in P.T. 1880, II.) on his endeavours to photograph spectra of stars. The spectrum apparatus used consists of one prism of Iceland spar and lenses of quartz, the length of the spectrum from G to O being about half an inch. The definition is so good that in photographs of the solar spectrum at least 7 lines can be counted between H and K with the width of slit employed, which is $\frac{1}{350}$ of an inch. The slit is placed in the primary focus of an 18-inch Cassegrain reflector. Particular care was taken to keep the image of the star on the slit; a small Galilean telescope was fixed in the hole in the large mirror and a polished silver plate with an opening somewhat larger than the slit was placed over the latter. This arrangement enabled the operator not only to watch the image of the star on the slit during the exposure but also, as was subsequently explained by Dr. Huggins, to move the image along the slit to give sufficient width to the spectrum. Gelatine plates were used. The slit has two shutters so that through half the slit a solar or other comparison spectrum can be obtained. The measures of the lines were reduced to wave-lengths by using M. Cornu's map of the ultra-violet spectrum, and M. Mascart's determination of the wave-lengths of the lines of cadmium. Photographs were obtained of the spectra of Sirius, Vega, α Cygni, Spica, η Ursæ maj., Altair, Arcturus, β Pegasi, Capella, α Herculis, α and β Orionis and Aldebaran. Also of Jupiter, Venus, and Mars, and of different small areas of the Moon, the latter under various illuminations and during eclipses, but no trace of absorptive action of a lunar atmosphere was found.

No. 3 of the first volume of Publications of the Astrophysical Observatory at Potsdam consists of Dr. Vogel's investigations of the Solar Spectrum. These embrace wave-lengths 480 to 500 mill. millim., examined optically by means of 4

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* A paper on "Variable stars of short period" by the same author, which has just been published, will be reviewed in a following number.

Rutherfurd prisms and two half-prisms, and wave-lengths 389 to 489 investigated photographically. Mechanical reasons as well as absorption did not permit a visual examination beyond G. The work was so trying to Dr. Vogel's eyes that he was unable completely to finish more than from *b* to E, but Dr. G. Müller extended the measures to the limits given above. The direct measures were made by a screw rotating a reflecting prism which turned the pencil into the viewing telescope, an X cross serving as pointer. Although remarking that the D lines are not adapted for testing a spectroscope Dr. Vogel informs us that the Potsdam instrument, by Schröder, shows 9 lines between these with a high sun when the air is damp and 7 lines when the air is drier. Their exact appearance is given in a wood-cut. More difficult tests are afforded by 11 lines near *b*; in particular at 531·61 is a very difficult line, first seen double by Professor Young. A double line at 495·67 is not very difficult. There are also good test lines near E. Judged by the mere agreement of the readings the mean of four measures was uncertain to $\frac{1}{240}$ of the interval between the D lines, but the final determinations based on Ångström and Cornu are considered uncertain to $\frac{1}{30}$ or $\frac{1}{20}$ of that interval. The measures were altogether differential, being referred to the fundamental spectrum by the formula—

$$w = \alpha + \beta d + \gamma d^2 + \delta d^3 + \ldots\ldots$$

where w is the wave-length, d the micrometer reading, and α, β, &c., constants to be determined by the method of least squares from the readings for known lines. The intenser lines were compared in width with spider's webs and expressed in numbers while the fainter lines are indicated in a descending scale by letters. Where necessary the lines are described as hazy on one or both sides. Finally all the lines were laid down on 8 charts by a drawing-pen with a divided screw-head. These drawings are reproduced by photo-lithography on about three times the scale of Ångström's normal spectrum. The importance of this magnificent contribution to the knowledge of the solar spectrum may be inferred from the fact that in two regions taken at random, one in each part, the Potsdam plates have 501 and 192 lines against 176 and 83 in the Normal Spectrum.

In photographing the spectrum the wet process was found to be the best. Fothergill's dry-plate method, as improved by Dr. O. Lohse, was found to be available only between the limits of W.L. 427 and 434. The original negatives, although $\frac{1}{3}$ the scale of Ångström's map, bore a magnifying power of 50, hence the greater amount of detail revealed. The photographs were measured under a power of 20 by a special apparatus made by Mr. Hilger. The measuring-screw, although practically perfect as regards equality of intervals, had considerable periodic errors which were, however, determined for no less than 10 portions of its length. In tabular form are given the number and means of the measures along with the chief details of the reductions to wave-lengths, to these are added the descriptions of the lines, their estimated or measured width, and, finally, the differences from the fundamental spectrum and occasional notes.

In the Mémoires de l'Académie impériale des sciences de St. Pétersbourg, VIIe série, T. XXVIII., No. 2, Dr. B. Hasselberg, in continuation of his spectroscopic researches, has collected all the published observations of Cometary Spectra and compared them with his own and other determinations of the spectra of Hydrocarbons. He considers the five well-known bands visible in the blue bases of candle, gas, and blow-pipe flames as, with a high degree of probability, due to Acetelene and quite distinct from the spectra of carbonic oxide or carbon. The spectroscopic observations of comets are passed in review and, where necessary, reduced to wave-lengths. There is a remarkable general accordance in the results, the most notable deviations being those by Huggins of the yellow and blue bands of Brorsen's comet in 1868, which, however, were not confirmed by Secchi's almost contemporaneous results, and of the same bands in Comet III., 1877, observed with considerable difficulty at Dun Echt. Excluding these it is shown :—

1. That all observed cometary spectra belong to one type.
2. That this type is that of the hydro-carbons.
3. That they deviate from the type in being incomplete and, in general, in the relative brightness of the bands.
4. They are incomplete in so far as the red and violet bands of the hydro-carbons are wanting, and, also, that the maximal brightness of the bands is not at the less refrangible edge but somewhat towards the violet.
5. This latter circumstance explains why in the case of faint comets the connexion with hydro-carbon spectra has appeared doubtful.
6. The displacement of the maxima of the bands of most comets, with regard to those of hydro-carbons, is approximately the same; therefore, it seems probable that the differences of the physical conditions of the hydro-carbons in the comets, from those which have hitherto been obtained in observations of hydro-carbon spectra, are approximately the same.

With respect to (4) it is important to note, as pointed out by the author, that Secchi saw both the red and violet bands, in addition to the three usual ones, in the spectrum of comet III. 1874.

The mean results for 18 comets compared with the spectrum of the hydro-carbons are—

	Band A.		Band B.		Band C.	
	Edge.	Max.	Edge.	Max.	Edge.	Max.
	mmm.	mmm.	mmm.	mmm.	mmm.	mmm.
Comets, . .	562·4	556·4	516·8	512·7	472·9	470·6
Hyd. Carb., .	563·4	—	516·4	—	473·7	—

The author then gives a full account of elaborate attempts to find if the hydrocarbon spectra can be made to show the deviations exhibited by those of comets. The most remarkable and successful experiment was with a Geissler tube containing a trace of Benzole; the tube was belted with tin-foil in the wide parts.

These foils were coupled with the wires of a spark-micrometer, and thence with the poles of a coil. On actuating the coil intense sparks sprang across the points while a green light appeared in the tube. This gave an almost pure hydro-carbon spectrum with only faint hydrogen lines. Compared with the spectrum of a benzole flame the violet band was very faint, while the maxima of the yellow and blue bands had moved towards the violet.

The induction-spark in a mixture of air or oxygen with hydro-carbon vapours, at the pressure of the air, gave, chiefly, an intense golden yellow light with a continuous spectrum, with the production of more or less lamp-black. Dr. Hasselberg considers these phenomena as not improbably allied to those observed in the nuclei of comets.

In "Mélanges physiques et chimiques," T. XI., the same author has an interesting paper on the spectroscopy of hydrogen. Wüllner in Pog. Ann., Bd. CXXV., p. 497, described what he considered to be a special form of the hydrogen spectrum. It was produced in a Geissler tube, containing a trace of hydrogen, by using a Leyden phial in conjunction with a powerful coil. While making allied experiments, Dr. Hasselberg obtained a similar spectrum between two terminals in a wide tube containing traces of air, whenever the spark was confined for a time within a certain short piece of glass tube. By careful measures of many lines the author showed that the spectrum was that of sulphur, and by changing the small tube he proved that the sulphur was thrown off by that tube under the conditions described.

M. Cornu, in Nos. 1-3 of the "Annales Scientifiques de l'école normale supérieure," extends his determinations of a normal ultra-violet spectrum to the utmost attainable limits. Of two beautifully engraved plates, the first from a little below *h* to O is reproduced with corrections from a former memoir, the second from O to U or from W.L. 340·00 to 294·78 contains the part now examined. Every precaution was taken to secure the greatest actinic effect. In the heliostat silvered mirrors were discarded for a total-reflecting prism of quartz. The spectroscope used to determine the finer detail had a prism of Iceland spar of 60° with the bisectrix of the right section perpendicular to the optical axis. M. Cornu would have preferred a prism with the edges parallel to the optical axis as the angle would then be constant at all temperatures. A grating of 100 to the millimeter by MM. Brunner and one by Nobert of 1801 lines (presumably in half a French inch) were used to find the wave-lengths. Collimator and telescope were both of $0^{m}·45$ focus with achromatized objectives of quartz and Iceland spar. The theory of these lenses is given in an appendix. A condensing lens of quartz was placed before the slit to ensure the use of the whole of the collimator objective. When the foci of the collimator and telescope were near the chief foci it was found that the sum of the conjugate readings of the focal scales was constant and characteristic of the ray observed. Guided by this theorem a table was constructed showing the positions of the telescope and prism as well as the focal readings of the collimator and telescope with the refrangibility as argument. Beyond the visual limit of the spectrum a

Soret fluorescent eye-piece (*vide* Journal de Physique, T. III., p. 255) permitted an immediate and close approximation to the exact photographic focus.

The exact deviation of the less refrangible rays was found by the method of duplex negatives taken at minimal deviation one above the other in reversed positions of the prism and the telescope. It is evident that the angle described by the telescope from one position to the other is double the deviation for the central ray in the negatives. An error of 6′ in the position of the prism corresponds to less than 1″ in the deviation. This method was available as far as W.L. 310. Beyond that point, at the season when the photographs were taken, October and November 1877, the sunlight was not strong enough to give more than one spectrum on the wet-plates used. This difficulty was overcome by means of duplex photographs of a comparison spectrum of iron, which also in this region has many lines in common with solar light. In this way the deviations for 19 lines beginning with O and extending beyond U to W.L. 292·86 were found and laid down on a chart $1^{m}\cdot85$ in length. About 800 lines were then intercalated from the negatives by means of a camera lucida. This prismatic spectrum had now to be reduced to wave-lengths by comparisons with a diffraction spectrum. For the fundamental determinations it was impossible to make much use of duplex negatives taken with either of the gratings. The work as far as S was mainly done with the Brunner grating used as a mirror sufficiently inclined to get D in the 3 first spectra on both sides of the reflected image of the slit. The observations of D gave the constant of the grating· The spectra of the same order not being equally bright on both sides, the brighter one of the 2nd order was photographed and the azimuth read off. The reflected image of the slit was then taken in two positions which with the corresponding readings gave the scale of the photograph and the deviation from the position of the reflected image. These data with the inclination and the constant of the grating gave the wave-lengths. Beyond S recourse was had to the Nobert grating and the spectrum of iron as afforded by 55 Bunsen elements. In this way W.L. 274·78 was reached, considerably beyond the limit of the solar spectrum as transmitted through our atmosphere. Between the wave-lengths of 18 lines thus found, all the other lines of the prismatic spectrum were interpolated by the reiterated use of the very convenient formula—

$$(x - a)(y - b) = c^2,$$

where a, b, and c^2 are constants determined by 3 known lines, x the wave-length, and y the deviation of any other line. M. Cornu concludes that the error of a wave-length cannot well exceed 0·25 millionths of a millimeter. From a comparison of the normal spectrum with those of 27 metals coincidences were established for all the strongest lines except three. With these exceptions all the important lines correspond to those of elements composing meteorites.

Professor Piazzi Smyth in a paper entitled "The Solar Spectrum at the Date 1877–1878" (Trans. of the Roy. Soc. of Edinburgh, Vol. XXIX.) gives a full account of the spectrum of a high sun as visible through glass. By skilful arrangements and favoured by the clear sky of Lisbon not only were three groups of lines preceding A rendered visible, but throughout the spectrum and particularly in the blue and violet very many lines not given by Ångström were laid down and described. While fully admitting the special advantages of wave-numbers for graphic representations of the whole spectrum, we consider it a matter of regret that although the measures are avowedly based on Ångström the results are not given in wave-lengths. A comparison of the part near *b* shows that the prisms used had not the separating power of the Potsdam spectroscope. The chief value of the work probably lies in the descriptions of the lines and colours which give, as it were, the complete physiognomy of the spectrum, thus helping to solve the "question in science whether the Solar radiations alter in quality with time, and if so in what manner and to what degree." In Part II. of the same paper it is pointed out that for six steps of increasing laboratory temperature the maximum frequency of lines moves towards the violet. When thus regarded the solar spectrum indicates a degree of heat vastly surpassing any that can be produced artificially.

In the "Observatory" for August to October 1880, we find again the Astronomer Royal for Scotland, under the head of "Practical Spectroscopy in 1880," while steadfastly advocating the use of wave-numbers, giving a wonderful amount of information about spectroscopic methods including that of end-on tubes and flames. He concludes by describing the great changes which two years' use produced in tubes containing air and Hydrochloric-acid, from which it seems probable that either the glass or terminals were capable of absorbing the nitrogen and chlorine, thus leaving a pure hydrogen spectrum. In the same way carbon was permanently thrown down from its compounds, but Iodine through being abundant in the tube and easily volatilized retained the power of showing its characteristic spectrum. These facts are of obvious importance to all users of Geissler tubes but seem to us capable of explanation in the way indicated without assuming hydrogen to be a compound or modification of any other elements.

In "Nature," Vol. XXII., Mr. Lockyer has a series of articles on "Multiple Spectra," in which it is maintained that the same element can produce various spectra according to the degree of heat to which it is subjected. Ångström and Thalén, and quite recently Messrs. Liveing and Dewar, whose views are stated at some length, maintained on the other hand that the fluted spectra were due to compounds, the elementary bodies merely producing lines. The question involves the whole *fundamenta* of Spectroscopy, and calls for new experiments with improved appliances.

Professor Pickering (American Journal, No. 118) using a spectroscopic eye-piece of 12′ field, while "sweeping" for heavenly bodies with remarkable spectra discovered three planetary nebulæ as mentioned above. On August 28 he found that Argelander-Oeltzen 17681 has a faint continuous spectrum with a bright band near each end, one being near D (580·0 to 585·0±), the other between F and G (467·0 to 473·0±). There was also a band at 5400, and some fainter ones were suspected.

Professor C. A. Young ("Spectroscopic Notes, 1879–80," Amer. Jour., No. 119) describes the double reversal of the magnesium lines of the *b* group, and of the two D-lines in the spectrum at the base of a prominence. He has succeeded in seeing the lines H and K reversed in the chromosphere whenever *h* can be seen, and, in view of the observations of Vogel, Draper, and Huggins, thinks they may be due to hydrogen.[*] H has always a fine companion line in the chromosphere which is wanting in the spot spectrum. This latter fact and observations of a prominence 13′ high, in which H and K were visible to the summit, but the companion only at the base, lead Professor Young to think that the companion line is not due to hydrogen. Of 70 lines given by Ångström as common to two or more elements, 56 were seen to be double or triple, and 7 uncertain when examined with a grating of 4 square inches surface. A concluding note explains the distortion of Solar Prominences by a diffraction spectroscope of the usual construction, and shows that it may be avoided by using the same tube and object-glass, both for collimator and view-telescope, the grating being slightly inclined.

Professor H. W. Vogel, in *Astronomische Nachrichten*, No. 2301, shows that four of the lines photographed by him in the spectrum of pure hydrogen agree almost absolutely with four of the violet and ultra-violet lines in Dr. Huggins' spectra of Vega and Sirius. There still remain[†] 6 lines unidentified beyond the range of Professor Vogel's spectrum, which was obtained with glass prisms.

The spectrum of comet 1880 *d* (Hartwig) was observed at Moscow,[1] O'Gyalla,[2] Princeton,[3] and Dun Echt.[4] As pointed out by Professor Young, the O'Gyalla results for the first and third bands differ much from the other measures. For the third or upper band the discordance can only be reconciled by assuming some misunderstanding about the comparison spectrum. The lower band was divided by Dr. von Konkoly, and seen with two feeble maxima at Dun Echt; but the wave-lengths do not agree. The chief maximum of the lower band as seen at Dun Echt accords with the Russian and Princeton results as well as can be expected for this most difficult band. The spectrum of comet 1880 *f* (Pechüle) was observed with extreme care by Dr. von Konkoly,[5] and under less favourable circumstances at Dun Echt.[6]

During the partial eclipse of the sun on December 31, 1880, M. Trouvelot[7] directed the slit of his spectroscope to the Moon's limb outside of the Sun. When less than 3′ or 4′ from the Sun, the presence of the satellite gave rise to "a very distinct broad grayish band spectrum, running along the brighter spectrum of the vicinity of the Sun. The conclusion is drawn that traces of the corona were thus rendered appreciable. The phenomenon was invisible in the northern regions of the sun, and brighter in the north-west than in the east.

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[*] In this connexion it is remarkable that K is wanting in the Spectra of Sirius, η Ursæ Majoris and α Virginis.

[†] Professor Vogel, however, in the *Photographic News* of Feb. 20, 1880, identifies one of these with a fifth of his hydrogen lines.

[1] Ast. Nach., No. 2345. [2] Ibid., No. 2348. [3] Ibid., No. 2350. [4] Vid. sup., p. 1. [5] Observatory No. 46. Vid. sup., p. 40. [7] *Science*, Jan. 10, 1881.

M. Thollon (*Compt. Rend.*, T. 91, p. 368) points out that two lines belonging to iron in the solar spectrum, have each a close companion of telluric origin, but on opposite sides. When the spectroscope is directed alternately to the western and eastern limbs of the sun, the iron lines are displaced with regard to the others by double the amount due to the rotatory velocity of the sun's surface, the displacement closing one pair, and opening the other. The wave-lengths of the iron lines are 597·61 and 597·46, those of the telluric lines, according to M. Thollon, 597·635 and 597·436. The observation of these lines is well calculated to dispel the last doubt as to the influence of the movement of a source of light on the wave-lengths.

In various numbers of the Comptes Rendus, particularly in T. 91, pp. 487 and 656, M. Thollon gives many interesting details of the distortion of the C line, and other phenomena in solar prominences and spots. At p. 520 M. Thollon draws particular attention to the desirability of exact observations of telluric lines; between the D-lines as many as ten are indicated as certainly, and one as possibly due to our atmosphere.

In the Phil. Trans. 1880, Part II., Captain Abney has published a map of the infra-red end of the solar spectrum, deduced from his photographs. It is remarkable how few sharply defined lines there are in the infra-red region, while there are a good many bands. Except in one or possibly two cases the lines were not seen thicker at sunset than when the sun was at a higher altitude, so that they do not appear to be of atmospheric origin.

13. *History of Astronomy; Bibliography.*

The "Monthly Notices," Vol. XL., contains two papers on Babylonian Astronomy by Mr. Bosanquet and Professor Sayce. The first paper describes two fragments of planispheres (on which, however, no configurations but only names of stars appear) and shows that the divisions of the circle which were employed by the Chaldeans are those into 8, 12, 120, 240, and 480 parts, but *not* into 360 parts. The second paper describes a tablet, possibly older than B.C. 1700, on which a number of heliacal and acronyctic risings of Venus are mentioned.

The second part of the "Mittheilungen des Coppernicus-Vereins für Wissenschaft und Kunst zu Thorn" (Thorn 1880, 8vo) contains two papers. The first of these is a resumé by Dr. Sigmund Günther of a letter to a friend, Wapowski, in which Copernicus in 1524 criticised Johannes Werner's "De motu octavae sphaerae tractatus." In this treatise Werner tried to determine the amount of the "trepidatio" or supposed variation of the precession of the equinoxes and to give an explanation of this imaginary phenomenon. Copernicus in his letter first points out a chronological mistake in Werner's arguments and next shows that Werner's explanation or theory does not produce the result the author wanted. Dr. Günther correctly remarks that Copernicus himself was to some extent a believer in the trepidatio, a time-honoured error which Tycho Brahe finally put an end to.

The second paper is a translation of a chapter of Dr. Malagola's book on Antonio Urceo, in which Copernicus' life as a student in Bologna (1496–1500) is described and illustrated by various documents. Copernicus belonged to the Natio Germanorum at the University of Bologna, he studied canonical law and Greek and under Domenico Maria Novara astronomy and possibly mathematics. He and his brother Andreas seem to have lived as students in very poor circumstances.

At the November meeting of the R. Astron. Society the Astronomer Royal gave a verbal description of an old engraving, representing one of Flamsteed's instruments. It seems to have been a sector for measuring the distance betwen two stars like Tycho Brahe's Sextans chalybeus, except that it is attached by a kind of adjustable T-head to the upper end of a polar axis. It is greatly to be wished that this picture may be published.

Two parts of the "Bibliographie générale de l'Astronomie" by MM Houzeau and Lancaster have appeared. They form the beginning of the second volume of the work (memoirs and papers), while the first volume (separate books) and the third one (observations) are to follow. The systematic arrangement of this bibliography leaves nothing to be desired. Vol. II. commences with a very complete catalogue of publications of learned societies and of scientific journals and reviews, then follows I.: History of Astronomy, II.: Biographies, III.: Spherical Astronomy, IV.: "Theoric Astronomy," V.: Celestial Mechanics, VI.: Physical Astronomy. This work promises to become one of the most useful handbooks that an astronomer can possibly refer to and it will no doubt save many papers and notes from oblivion and facilitate a thorough knowledge of past and present literature. The two parts so far published contain more than 500 pages, mostly printed in double columns.

Professor Holden has prepared a list of all the indexes to scientific periodicals relating to Astronomy and kindred subjects, which are in the library of the U.S. Naval Observatory, together with a list of works on scientific bibliography (Catalogue of the library of the U.S. Naval Observatory, Part I., 10 pp., 4to).

The same author has also compiled a "Subject Index to the Publications of the U.S. Naval Observatory, 1845–1875" (74 pp., 4to). This index forms an excellent guide to the very numerous observations, results, and discussions which have emanated from the Washington Observatory during thirty years, and it is very much to be hoped that other observatories may feel induced to furnish us with similar indexes.

14. *Instruments.*

The apparatus invented by M. Loewy for determining the flexure of the tube of a transit circle has been tried at the Paris Observatory with perfect success. It will be remembered that the apparatus consists of a convex lens placed in the centre of the cube of the telescope, the concavity being turned towards the eye-piece and having a radius equal to the distance from the focal plane. A reflected image of a horizontal wire will, in this way, be formed by the side of the wire, and the flexure of the eye-end of the tube will be found as the tube is moved. The convex surface of the lens is of such a radius that its focal length is one-fourth of that of the object-glass, so that the image of a point on the latter is also formed next the wire. The effect of a displacement of the small lens (for instance by its own weight) is detected by watching the image of a point in one of the pivots, reflected from a small plane surface on one side of the lens. The influence of the weight of the apparatus has been studied by attaching small weights to the lens, and the influence was found to be in exact proportion to the amount of weights, and when it was eliminated the different values for the flexure were in very good accordance *inter se.* The horizontal flexure of the great meridian circle was, with this apparatus, found = $1''\cdot03$, while the horizontal collimators gave $1''\cdot15$. The flexure does not seem to vary as the sine of zenith distance. (Comptes Rendus, XCI., p. 6.)

Messrs. Burton and Grubb have in the "Monthly Notices" (Vol. XLI., No. 2[*]) described a new form of "ghost micrometer," or micrometer in which only images of wires instead of the material wires are used for measuring. Similar instruments have already been devised by Lamont, K. von Littrow, Stampfer, and Bidder. In the micrometer constructed by Mr. Grubb and Mr. Burton the ghost images are formed by a perforated achromatic lens, through the hole in which the rays of the star observed pass from the object-glass to the eye-piece. It has been tested as regards the effect of the images of the wires or lines on the images of various celestial objects and not the slightest change of form or false light was found in any case.

Dr. H. C. Vogel has made an interesting comparison as regards colour-correction between the various refractors at the Potsdam and Berlin Observatories.[†] By placing a small direct-vision prism in front of the eye-piece, the spectrum is spread out in a trumpet-like shape towards both ends, while there are two points at which the spectrum is reduced to a line. These nodes move towards the ends of the spectrum when the eye-piece is drawn out, and the focus for rays of any wave-length may be found by making the nodal point fall at the corresponding part of the spectrum. The distance through which the eye-piece has been drawn out gives the longitudinal chromatic aberration for the colour in question. Dr. Vogel has drawn curves showing the chromatic aberration for the different parts of the spectrum for each of the object-glasses examined.

Dr. Meyer has published a "Note sur l'emploi du microphone dans le service de l'heure astronomique,"[‡] describing an arrangement introduced last summer at the Geneva Observatory. A microphone is fixed on the outside of the case of the standard clock, and placed in circuit with a single Maidinger element, and a telephone. The beats of the clock can be heard in the latter, and by means of a commutator a second telephone in another room can be inserted in the circuit, so that various clocks can be compared conveniently with the normal clock.[*]

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[*] Also in the Proc. R. Dublin Society, Vol. 3, in an article which also describes the various forms of micrometer illumination now in use.

[†] Monatsberichte der Berliner Akad. d. Wiss., 29 April, 1880 The method used by Dr. Vogel is not new, but has been used at several Observatories. Vid. Astr. Nachr., No. 1867, d'Arrest: Nebulose Stjerner (1872), p. 7 & seq., Amer. Journal, June, 1880.

[‡] Archives des sciences physiques et naturelles, Jan., 1881.

The Earl of Rosse has described some recent improvements in the mountings of the telescopes at Birr Castle (Phil. Trans. 1880, Part 1). In 1869 a clock-movement was applied to the 6-foot reflector, which has been found fairly satisfactory, and which has made it possible to take accurate micrometer measures with that instrument. In the spring of 1874, the 3-foot reflector which had then been in use as an altazimuth for nearly 35 years, was dismounted, and in 1876 a new equatoreal mounting was finished and put up. This mounting, which has been found perfectly steady, even in a strong wind, is in the main principles of novel construction. The " tube " is square, made of angle-iron, it is suspended between the two prongs of a large hollow fork (made of boiler-plate), the lower end of which is turned down under the lower end of the polar axis and carries a counterpoise. The centre of the declination axis (or rather the point midway between the cylindrical trunnions on which the tube turns) is exactly in a line with the prolongation of the polar axis. The observer stands in a "cage" suspended at one end of an arm, the other end of which carries a counterpoise. He has both the altitude and azimuth motion of the cage under his own control, while an attendant on the ground can very easily move the gallery whenever necessary round on the circular rail which surrounds the whole instrument. The telescope is moved by clockwork, and when fitted with an electric control and readers for the two circles available from the eye-end, it will be a most convenient and powerful instrument.

Herr Schneider has constructed a comet-seeker of 4½ feet focal length and 6 inches aperture for the Vienna Observatory. The eye-piece remains at rest wherever the telescope is turned, as it is both in the prolongation of the declination axis and of the polar axis. The tube is balanced on the declination axis by a counterpoise, and the excess of weight on one side of the polar axis is also balanced.[†]

Messrs. Alvan Clark and Sons have a considerable number of large refractors on hand in all stages of completion. The lenses of a 23-inch for Prof. Young at Princeton are finished and have been pronounced excellent by that astronomer. A 16-inch glass for the Warner Observatory at Rochester is finished and the mounting nearly so. The M'Cormick glass of 26 inches aperture is still in the shop, where the mounting is being completed; it is intended for the University of Virginia. The flint glass disc for the 30-inch Pulkova refractor has been received from MM. Feil and the crown glass is expected shortly (the mounting is, we believe, ordered from Messrs. Repsold). A 36-inch glass has been ordered for the Lick Observatory.[‡]

[*] For the last three years or more a telephone has been used at Dunsink in the circuit of the M. T. Standard Clock, which sympathetically controls two clocks in Dublin. The telephone is placed next the Sidereal clock in the Meridian room, and the beats of the M. T. clock being heard in the telephone, the two clocks can be compared without carrying a chronometer backwards and forwards.

[†] Carl's Repertorium für Experimental Physik; "Nature," XXXIII., p. 88.

[‡] "Science" 31 Dec. 1880, & 12 Mar. 1881.

M. Martin is engaged in polishing the object-glass of 0·73 meter diameter for the Paris Observatory. Messrs. Paul and Prosper Henry are making the object-glass ($0^{m}\cdot76$ aperture) and M. Eichens the mounting of the refractor for the observatory at Nice.

The 27-inch refractor, constructed by Mr. Howard Grubb for the Vienna Observatory, is now completed and appears to be a perfect success. The mounting was already finished in 1878 when the British Association met in Dublin. It is in the main parts constructed on the same principles as Mr. Grubb's other equatoreals. The intersection of the polar and declination axes is placed so as to allow circumpolar motion to all objects south of the zenith. Both the polar and the declination axes are furnished with antifrictional apparatus which can be adjusted to the greatest nicety. The tube can be moved rapidly in Right Ascension, either by an assistant standing on the ground at the south end of the pier, where a handwheel by means of shafts and gearings communicates motion to the instrument, or by the observer from his place at the eye-end, where he by turning a shaft can command either of the two motions. If the tube is clamped in declination the shaft causes it to move in R.A., and if the tube is clamped in R.A. the shaft moves it in declination. There are of course also slow motions available at the eye-end. The clockwork consists of a uniform motion clock controlled by a frictional governor and a system of electric control on the same plan as that constructed by Mr. Grubb for Dr. Huggins. Both the R.A. and the declination circles are read from the eye-end of the tube through one and the same reading telescope, which by being turned 90° on its axis brings the vernier of either circle into the field of view.

Perfect discs of glass were not received from Messrs. Feil until October 1879, when the work of making the object-glass was at once proceeded with. This, the largest object-glass yet made, appears also, so far as we have been able to judge, to be the best produced by Mr. Grubb. The general impression afforded by the images is one of great cleanness, with a consequent blackness of field close up to bright objects. Even on nights when the definition is not very good a star's image inside the focus is still satisfactorily uniform in brightness, while the central blue rays seen outside the focus are very much less intense than in older and much smaller object-glasses of allied construction. On the other hand there seems to be no trace of under-correction, even with so decidedly yellow a star as γ Leonis. Sirius is a magnificent object, sharp and clear; the companion is of course very conspicuous. The nebula in Orion will well repay a careful study, as the image of it shown by the 27-inch glass is comparable in brightness with that seen in Lord Rosse's 6-foot reflector. More remarkable is, perhaps, the view given of the faint and diffused masses of nebulosity following ζ Orionis (G.C. 1227), which most difficult object appears so bright and clear as to surprise anybody acquainted with its appearance even in powerful telescopes.

15. *Observatories.*

A short description of the new Strassburg Observatory (with plans of the buildings) is given in the Vierteljahrsschrift (XIV., p. 328). The 18-inch refractor by Merz has recently been mounted under a large dome which is moved by machinery. A separate building contains a meridian circle by Repsold, an altazimuth, and an orbit sweeper. The dwelling-house is connected with the two other buildings by covered corridors.

The observatory at Mannheim has been moved to Carlsruhe.

The observatory at Nice is approaching completion; it is situated a few kilometers north east of Nice, and will be furnished with first-class instruments. The Etna Observatory is also progressing. Professor Langley has, in the July number of the "American Journal," given an account of his observations on Mount Etna in 1878. The gain over a lower station, as found by double star tests, was more in clearness of the atmosphere than in that freedom from tremor which accompanies good definition. The latter was, indeed, on the whole, better than below, but not conspicuously so.

M. Cruls has published a pamphlet entitled "Notice sur l'Observatoire Impérial de Rio de Janeiro (Rio de J. 1880, 16 pp. 8vo). Of the several original and ingenious instrumental contrivances at the observatory of Rio de Janeiro we shall here only mention one. For the transit instrument and the meridian circle the axes respectively of an altazimuth and of a prime vertical transit serve as collimators, while the two latter instruments can also be collimated on one another.

Mr. Lewis Swift, who has for many years so successfully searched the heavens with a small instrument, will in future have at his disposal the 16-inch refractor at the "Warner Observatory," in Rochester, N.Y.

Professor Holden has been detached from the Naval Observatory to take charge of the Washburn Observatory of the University of Wisconsin. The sudden death of Professor Watson left his plans in a very unfinished state, as he had only partially completed a "solar observatory" where he hoped to re-discover the intramercurial planet which he believed he had seen during the total eclipse of 1878. At the bottom of a hill, sloping at an angle of about 45°, a small building with a deep cellar was built, and a tunnel about 18 inches in diameter and fifty-five feet long, parallel to the Earth's axis, connects this cellar with a pier at the top of the hill, which is to support a heliostat. The object of the long tunnel is to cut off as much of the stray light as possible, and to enable the observer to examine objects close to the Sun's limb ("Science," Feb. 19, 1881).

The Washburn Observatory is provided with a 16-inch refractor by Clark, which is ready for use. Mr. Burnham's General Catalogue of Double Stars will probably form one of the first volumes of the Annals of this observatory.

BEOBACHTUNGEN KLEINER PLANETEN AM REICHENBACH'SCHEN MERIDIANKREISE ZU GÖTTINGEN.

Mitgetheilt vom Director, Professor Dr. Klinkerfues.

1880. Datum.	Mittlere Göttinger Zeit.	Planet — *.		Planet.		Par. π = 8″·90.	Beob — Eph. (Berl. Jahrb.)		Gewicht.	Vergleichsterne.
		Δα.	Δδ.	App. α.	App. δ.					
				(3) Juno.						
	H. M. S.	H. M. S.	° ′ ″	H. M. S.	° ′ ″	″	s.	″		
Feb. 7,	13 25 42	—0 23 5·22	— 6 21 40·2	10 35 46·95	+ 1 37 7·0	4·07	+ 4·90	— 10·3	10·0	χ Leonis B. V.
—	—	+ 1 27 36·99	— 1 11 53·2	46·96	5·6	—	+ 4·89	— 10·7	11·3	θ Hydræ „
„ 9,	13 16 20	+ 1 26 7·09	— 0 54 33·4	10 34 17·08	+ 1 54 25·1	4·06	+ 4·79	— 10·6	10·3	„ „ „
Mar. 12,	10 47 25	— 0 33 39·33	— 4 3 44·4	10 9 20·37	+ 7 6 45·7	3·52	+ 4·86	— 8·7	13·9	l Leonis „
				(4) Vesta.						
Mai 25,	12 40 8	+ 0 30 2·27	+ 0 32 16·5	16 55 53·82	— 15 11 19·8	7·06	+ 1·52	+ 0·8	14·0	1.
Juni 17,	10 47 11	— 0 30 15·02	— 0 30 2·0	16 33 18·85	— 16 4 37·1	7·00	+ 1·49	+ 3·8	15·0	η Ophiuchi N. A.
				(5) Astræa.						
Mai 1,	12 8 49	— 1 22 10·15	— 2 38 36·5	14 49 51·46	— 7 2 45·3	5·22	— 6·29	+ 21·6	8·4	ε Ophiuchi B. V.
„ 4,	11 54 19	+ 1 43 21·39	— 1 55 44·4	14 47 8·81	— 6 49 57·7	5·12	— 6·33	+ 23·9	6·9	θ Virginis „
„ 9,	11 30 17	— 1 29 18·60	— 2 6 46·4	14 42 43·09	— 6 30 54·9	5·05	— 6·21	+ 28·0	20·9	ε Ophiuchi „
„ 10,	11 25 27	— 2 21 41·40	—	14 41 51·91	—	—	— 6·28	—	—	η Ophiuchi N. A.
„ 11,	11 20 40	— 2 13 47·19	— 2 21 35·8	14 41 0·14	— 6 24 12·5	5·02	— 6·22	+ 29·3	15·1	2 = 30 Ophiuchi.
„ 12,	11 15 53	+ 0 24 18·46	— 4 54 27·5	14 40 9·50	— 6 21 4·3	5·00	— 6·38	+ 29·7	15·5	3 = 103 Virginis.
„ 13,	11 11 8	+ 0 29 33·20	— 0 52 7·4	14 39 19·78	— 6 18 4·6	4·98	— 6·32	+ 29·9	10·9	ι Virginis B. V.
				(6) Hebe.						
März 12,	12 32 41	+ 2 2 45·69	+ 5 53 28·7	11 56 40·84	+ 14 30 23·0	2·82	+ 6·12	+ 4·4	8·1	π Leonis B. V.
„ 13,	12 29 58	+ 1 12 49·60	+ 3 29 12·1	11 55 49·50	+ 14 39 42·2	2·80	+ 6·11	+ 1·9	6·8	l Leonis „
„ 17,	12 8 56	— 2 0 31·70	+ 0 1 51·0	11 52 23·49	+ 15 15 41·5	2·75	+ 6·52	+ 1·0	20·7	4.
				(7) Iris.						
Juni 17,	13 20 26	+ 2 3 25·35	— 4 7 55·4	19 6 59·22	— 19 42 30·5	5·21	+ 3·20	— 5·6	16·3	η Ophiuchi N. A.
Juli 18,	10 47 2	— 0 26 25·27	+ 0 10 20·0	18 34 52·85	— 19 18 8·7	4·79	+ 3·19	+ 0·6	15·0	5.
				(11) Parthenope.						
Feb. 1,	13 41 41	+ 0 34 13·76	—	10 28 8·74	—	—	+ 4·67	—	—	π Leonis B. V.
„ 6,	13 18 8	+ 0 30 19·97	+ 4 18 29·2	10 24 15·01	+ 12 55 24·9	3·18	+ 4·62	— 4·6	8·8	„ „
„ 7,	13 13 22	+ 0 29 30·27	+ 4 25 3·3	10 23 25·32	+ 13 1 58·9	3·19	+ 4·59	— 10·3	9·1	„ „

(14) Irene.									
Mai 7, .	11 26 29	+1 27 17·09	—	14 31 4·46	—	—	—	—	—	θ Virginis B. V.
„ 9, .	11 16 52	−1 14 16·52	+ 0 29 48·4	14 29 18·41	− 2 34 7·7	5·64	—	—	16·2	μ Serpentis „
„ 11, .	11 7 16	−2 27 12·65	+ 1 25 47·3	14 27 34·68	− 2 36 49·4	5·62	—	—	14·7	2 = 30 Ophiuchi.
„ 12, .	11 2 30	+0 10 53·10	− 1 11 49·3	14 26 44·14	− 2 38 26·1	5·61	—	—	17·5	3 = 103 Virginis.
„ 13, .	10 57 45	+0 16 8·14	+ 2 45 42·0	14 25 54·71	− 2 40 15·0	5·60	—	—	19·2	ι Virginis B. V.
„ 30, .	9 40 9	−1 27 35·43	− 0 10 30·7	14 15 7·98	− 3 37 37·9	5·23	—	—	7·9	6 = 30 Serpentis.
(15) Eunomia.										
März 17, .	12 57 40	−1 49 45·83	+ 0 12 43·1	12 41 25·76	−22 26 1·5	3·88	+9·42	−50·2	8·4	7.
Apr. 6, .	11 21 23	−2 55 28·17	− 0 10 51·0	12 23 43·97	−21 8 31·9	3·93	+9·78	−64·8	20·7	8.
„ 17, .	10 29 13	−2 55 47·78	−11 6 20·1	12 14 48·44	−20 2 56·6	3·86	+9·24	−70·2	10·0	β Libræ B. V.
(20) Massalia.										
Feb. 1, .	13 33 39	+0 16 9·43	+ 1 30 27·3	10 10 4·41	+10 7 23·3	5·82	+22·32	−125·0	9·3	π Leonis B. V.
(40) Harmonia.										
Apr. 17, .	12 14 37	−1 10 6·34	+ 3 47 9·5	14 0 29·92	− 5 9 27·0	5·44	+3·16	−22·6	8·1	β Libræ B. V.
Mai 4, .	10 51 31	+0 40 22·96	—	13 44 10·34	—	5·28	+2·81	—	—	θ Virginis „
„ 7, .	10 37 10	+0 37 49·98	+ 0 59 47·8	13 41 37·35	− 3 54 25·5	5·23	+2·77	−22·8	8·2	„ „ „
„ 9, .	10 27 43	−2 3 23·60	− 0 45 58·9	13 40 1·33	− 3 49 55·0	5·21	+2·81	−19·6	14·5	μ Serpentis „
(43) Ariadne.										
Mai 1, .	12 29 25	−1 28 48·46	− 0 16 11·9	15 10 31·12	−22 22 7·2	9·04	+3·42	− 9·9	15·2	9.
„ 4, .	12 14 48	+2 3 54·81	−17 11 52·2	15 7 42·19	−22 6 5·5	9·11	+3·61	− 9·0	14·7	θ Virginis B. V.
„ 9, .	11 50 18	−0 52 4·40	+ 0 2 5·7	15 2 50·89	−21 36 34·0	9·20	+4·45	− 8·4	16·6	10.
„ 11, .	11 40 29	−1 30 18·80	+ 1 15 8·9	15 0 53·19	−21 23 50·9	9·22	+4·58	− 6·8	9·8	11.
„ 12, .	11 35 34	−0 25 20·43	+ 2 10 54·0	14 59 54·00	−21 17 33·0	9·22	+4·05	− 8·4	10·3	12.
„ 30, .	10 9 45	−0 21 44·62	− 0 5 49·8	14 44 48·42	−19 17 50·2	8·96	+4·24	− 9·9	7·4	13.
(51) Nemausa.										
Apr. 7, .	12 27 50	+2 3 27·44	− 1 24 41·8	13 34 18·62	− 1 34 42·5	5·77	+5·33	+91·6	6·5	ν Leonis B. V.
„ 17, .	11 41 20	—	+ 0 2 46·9	—	+ 0 7 48·2	5·63	—	+91·5	10·0	14.
(78) Diana.										
März 12, .	12 51 17	−0 48 27·56	− 4 20 28·4	12 15 19·48	− 9 14 40·1	5·91	−8·79	+78·0	7·6	θ Virginis B. V.
„ 13, .	12 46 23	−0 21 15·78	− 8 26 4·5	12 14 21·87	− 9 13 49·7	5·90	−8·27	+79·2	8·2	γ „ „
„ 15, .	12 36 35	−1 20 0·15	+ 0 5 8·8	12 12 24·23	− 9 11 39·6	5·88	−8·04	+83·1	16·6	15.
(119) Althæa.										
März 12, .	12 36 35	−1 3 20·97	− 1 5 58·7	11 32 16·67	− 1 53 43·8	3·97	+5·73	− 2·3	5·8	γ Virginis B. V.

POSITIONEN DER BENUTZTEN VERGLEICHSTERNE.

No.	Mittlerer Ort. 1880·0 (Auwers).		Corr. auf den Sch. Ort.		Autorität.
	α.	δ.	Δα.	Δδ.	
	H. M. S.	° ′ ″	S.	″	
1	16 25 47·71	—15 43 26·3	+ 3·84	—10·0	½ (Argelander Oeltzen, südl. Zonen 15720 + 15721).
2	16 54 43·95	— 4 2 27·0	+ 3·38	— 9·7	$\frac{1}{11}$ (2 B.A.C. 5724 + 2 Rümker XVI. 5624 + 2 Yarnall 7049 + 5 Mädler 2159).
3	14 15 47·71	— 1 26 19·7	+ 3·33	—17·1	$\frac{1}{15}$ (2 B.A.C. 4762 + 2 Lamont 4352 + 5 Mädler 1858 + 2 Lalande $24\frac{299}{300}$ + 2 Bessel XIV. 251 + Schjellerup 5106 + Rümker 4666).
4	13 52 52·45	+15 14 11·7	+ 2·74	—21·2	¼ (Bessel 1140 + 3 Rümker 4532).
5	19 1 13·54	—19 28 35·3	+ 4·58	+ 6·6	¼ (Arg. Oeltz. 19110 + 3 Yarnall 8142).
6	15 42 39·78	— 3 26 56·4	+ 3·63	—10·8	$\frac{1}{11}$ (2 B.A.C. 5226 + 5 Mädler 1999 + 2 Lalande 28783,4 + 2 Armagh 3285).
7	14 31 8·75	— 22 38 31·6	+ 2·84	—13·0	¼ (Lalande 26633 + Arg. Oeltz. 13768 + 2 Argelander Bonn Mer. Beob.).
8	15 19 8·91	—20 57 27·4	+ 3·23	—13·5	⅙ (3 Yarnall 6342 + 2 Arg. Oeltz. 14544 + Lalande 28090).
9	16 39 16·01	—22 5 46·7	+ 3·57	— 8·6	Bonn Mer. Beob. Zone — 14° 20′ bis — 31° 20′ XIV., No. 50.
10	15 54 51·56	—21 38 26·7	+ 3·73	—13·0	¼ (3 Bonn M. B. Zone — 14° 20′ bis — 31° 20′ XIV., No. 90 + Lalande 29113).
11	16 31 8·10	—22 38 50·6	+ 3·89	— 9·2	½ (Bonn M. B. XIV., No. 41 + Yarnall 6853).
12	15 25 10·63	—23 28 12·2	+ 3·80	—14·8	¼ (Arg Oeltz. 14621 + 3 Yarnall 6379).
13	15 6 29·25	—19 11 37·3	+ 3·79	—23·1	⅓ (Arg. Oeltz. 14363 + 2 Yarnall 6255).
14	14 47 40·45	+ 0 5 18·9	+ 3·12	—17·6	⅕ (2 Lamont 4526 + 2 Bessel XIV., 874 + Lalande 27118).
15	13 32 21·57	— 9 16 30·8	+ 2·81	—17·6	Lamont 13551.

In Ermangelung einer Vorrichtung zur Beobachtung mit hellen Fäden wurde im Focus des Fernrohrs ein System von Ringen angebracht und die Anordnung so getroffen, dass ein die Mitte des Gesichtsfeldes passirendes Object die beiden mittleren concentrischen Ringe längs des horizontalen Durchmessers durchlief, während er in den beiden äusseren zu beiden Seiten dieser mittleren liegenden Ringe nur sehr kleine Sehnen beschrieb. Die Mittelpunkte der beiden letztgenannten Ringe lagen ausserdem an verschiedenen Seiten des Parallels der Mitte des Gesichtsfeldes. Die Radien der Ringe, die während der Beobachtungen verschiedene Male bestimmt wurden, waren im Mittel:

Rectascensionskreise:	I.	19′ 41″·64	15′ 47″·50
	II.	9′ 20″·27	5′ 56″·50
Declinationskreise:		9′ 10″·24	5′ 33″·38
		9′ 8″·81	5′ 33″·86

Aeusserlich gleicht der Auszug des Fernrohrs ganz dem gewöhnlich bei Passagen-instrumenten verwendeten. Selbst die Fädenplatte hat ganz die gewöhnliche Form. Auf die ringförmige Blende derselben sind die Fäden, wie in fig. 2. gezogen Hinten ist aber in die Platte eine Nute *a* fig. 1 eingedreht und in diese ist die

Planplatte fig. 3 mit den Ringen gelegt. Man kann bei dieser Einrichtung also einmal das Fadennetz justiren, dann aber auch das Ringsystem so drehen dass die beiden Parallelfäden in den äusseren Declinationsringen beliebig kleine Sehnen bestimmen. Zur Vermeidung einer Parallaxe muss natürlich die Ebene der Fäden mit derjenigen der Ringe fast genau zusammenfallen, was beim Göttinger Mikrometer in der That erreicht ist. Die Mikrometerringe sind übrigens aus Stahl angefertigt und in entsprechende Nuten der Glasplatte eingelassen und festgekittet.

Die Beobachtungen wurden nach der Auge- und Ohr-Methode bis auf Zehntel Zeitsecunden genau erhalten. Für die Declinationen wurden stets alle vier Mikroscope abgelesen. Die mitgetheilten Rectascensionen beruhen grösstentheils auf Vergleichung mit mehreren an demselben Abende beobachteten Sternen des Berliner Sternverzeichnisses (durch B.V. angedeutet). Die Declination wurde wo möglich immer an einen gut bestimmten Stern von wenig verschiedener Declination angeschlossen, den man in der elften Columne angegeben findet. Wenn durch eintretende Bewölkung oder andere Behinderung die Beobachtung eines passenden Sternes vereitelt wurde, ist bei der Reduction der Beobachtung auf die Befreiung derselben von dem Einflusse der Instrumentalfehler eine besondere Sorgfalt verwendet. Die zehnte Columne giebt ein freilich nur relatives Gewicht der aus den Sehnen abgeleiteten Declinations-Differenzen an. Dabei wurde einer Beobachtung, welche einem Fehler von 1″ in dem daraus abgeleiteten Abstande gegen den Mittelpunkt des Ringes entspricht, das Gewicht 1 beigelegt. Es ergab sich als Mittel aus 6 Berechnungen der dem Gewichte 10·0 entsprechende wahrscheinliche Fehler zu ± 0″·72.

Bei Gelegenheit der Reduction bemerkte ich noch, dass bei Lalande 26633 die Rectascension um 10ˢ zu klein angesetzt ist.

Dr. H. Kobold,
Observator der Sternwarte O'Gyalla.

THE CHROMOSPHERE IN 1880.

By the Rev. S. J. PERRY.

A comparison of the results obtained during a twelvemonth's examination of the chromosphere leads to the conclusion that the solar forces have increased greatly in activity, but the prevalence of cloudy weather, especially during the summer months, diminishes very materially the value of the series of observations. Scarcely any opportunities of obtaining reliable measures were neglected, and yet observations were made on only 64 days, the smallness of this number being due partly to cloudy skies, but not unfrequently to the strong atmospheric spectrum, which rendered abortive any attempts to procure a trustworthy record of the varying height of the solar envelope.

The instrument employed in these measures is an automatic spectroscope by Browning with an adapter by which the slit, placed normally or tangentially to the Sun's limb, can be made to sweep rapidly round the circumference by aid of a rack and pinion. A dispersion of 8 prisms of 60° was generally used, but occasionally the dispersion was increased to 10 prisms, or diminished to 6 or 4, and even on one occasion to 2 prisms. The height of the chromosphere is read on a photographic scale whose divisions are tenths of millimetres, and the readings are taken to the tenths of the divisions. The value of each division is 4″·27.

In the following table those results only are included in the means which were obtained on days when the whole chromosphere was examined.

1880.	Number of Days of Observation.	Mean Height of Chromosphere, excluding Prominences.	Mean Extent of Prominence Arc.	Mean Height of Prominences.	Highest Prominence.
January, . . .	3	7″·9	7° 34′ 15″	21″·1	59″·0
February, . . .	3	7·7	7 52 0	21·5	52·5
March, . . .	7	8·1	24 35 40	21·9	60·2
April, . . .	2	8·1	27 3 45	21·4	41·9
May, ...	12	8·1	24 45 50	25·8	68·4
June, ...	2	8·1	15 15 0	20·9	54·7
July, ...	2	7·7	25 17 0	17·5	75·2
August, . . .	5	8·1	28 5 0	21·1	59·8
September, . . .	2	7·5	15 49 15	25·0	53·4
October, . . .	7	7·7	37 33 30	23·2	63·2
November, . . .	12	7·9	33 51 0	36·0	147·9
December, . . .	7	8·3	32 34 25	26·1	72·6

The highest Prominence observed during the year was 2′ 27″·9, or about 66000 miles. This was seen on November the 4th. The previous day a Prominence on the same part of the Sun's limb measured 2′12″·9. The mean height of the chromosphere for the year is 7″·93 or 3550 miles. The increase of activity during the year is particularly noticeable if we compare the first three months with the last three, the mean height of the Prominences being respectively 50″·3 and 66″·5, and their extent along the solar limb 13° and 35°.

Stonyhurst College Observatory.

12 FEB OXFORD

SUR LES QUEUES DES COMÈTES.

PAR TH. BREDICHIN.

§ 1. La queue d'une comète dans son développement complet se présente comme un conoïde creux ; le vide intérieur se manifeste par la bande obscure, qu'on voit au milieu de la queue. Le conoïde de la queue est formé des effluves de la matière qui émane du noyau, se dirige d'abord vers le soleil, puis rebrousse chemin et va former les bords du conoïde. Ce fait est maintenant trop bien connu pour qu'il soit nécessaire de le confirmer par une description détaillée de quelques comètes. Il nous suffira de citer les cas, où on voit avec plus d'évidence l'action de la force répulsive du soleil sur la matière émise par le noyau. Ces cas nous sont offerts par les comètes dont la distance périhélie est courte et qui par conséquent s'approchent et s'éloignent du soleil sous des angles très aigus avec les rayons vecteurs. Il est évident que parmi ces comètes, les plus favorables à servir de critérium à la théorie sont celles, dont les queues ont été observées après le périhélie. Il est important de se persuader, que lors même que le noyau s'éloigne rapidement du soleil, la matière émise par lui s'élance d'abord vers l'astre central et que ce n'est que plus tard qu'elle devance le noyau et forme la queue située à l'opposite du soleil.

Les comètes à petite distance périhélie q sont celles des années: 1680, 1744, 1769, 1821, 1865 I et 1880 I.

La comète de 1680 ($q = 0\cdot006$) a été observée par Hooke après le périhélie, quand l'angle β formé par la direction du mouvement avec le rayon vecteur n'était que 6° ; on sait avec quelle exactitude Hooke a décrit la formation de la queue par des effluves du noyau et qu'il a déduit de ces observations les conséquences suivantes :[*] ". . . . . Secondly, that there is a gravitation *towards,* and a levitation *from* the sun. For, as I have by many observations shown, though there be a descent of the streams from the nucleus *towards* the sun, yet I always plainly saw that they quickly *returned,* and went contrary and *opposite* to the sun, and that sometimes to a prodigious extent."

Dans la comète de 1744 ($q = 0\cdot22$) le développement de la queue a été observée avant le périhélie, quand $\beta = 30°$, et nous en avons une description classique faite par Heinsius.[†]

La comète de 1769 ($q = 0\cdot12$), avant le périhélie avait une queue énorme avec la bande obscure au milieu. On trouve sa description et ses dessins dans le mémoire de Messier. Après le périhélie ($\beta = 20°$), quoique la queue fût très courte, elle offrait néanmoins les indices certains du mode de sa formation :[‡] "Le 4 novembre . . . . je l'examinai (la queue) avec une lunette achromatique à double objectif, de cinq pieds de foyer, qui grossissait peu, et j'observai comme au mois de septembre (avant le périhélie), que sur les deux bords de la queue près du noyau, la lumière était plus forte que dans le milieu de la queue. Le 6 novembre . . . . les mêmes effets pour la queue avaient lieu, comme dans l'article précédent; la grande lumière de la lune nuisait un peu à ces observations."

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[*] "Month. Not. of the R. A. Soc.;" Vol. XIV., pp. 77–79.

[†] Heinsius; Beschreibung des im Anfang des Jahrs 1744 erschien. Cometen.

[‡] Messier; Mémoires de l'Acad. de Paris, 1775, p. 410.

Dans la comète de 1821 (q = 0·09) observée avant le périhélie (β = 18°) la queue avait la forme très prononcée d'un conoïde creux.[*]

La comète de 1865 I (q = 0·03) a été observée par M. Moesta après le périhélie, à l'angle β = 15° et elle avait la forme suivante :[†] "Am 20. Januar. Der Kern war nicht rund, sondern der Kopf hatte die in der Figur angedeutete Form, wonach eine Ausströmung aus dem Kerne ersichtlich ist. . . . Am 21. Januar war die Ausströmung deutlicher zu sehen; der Kern zeigte die Form eines Sectors. . . Der südliche Rand (bord antérieur) war sehr scharf begrenzt."

Dans la comète de 1880 I. (q = 0·006) le noyau et la tête se trouvaient toujours dans le brouillard de l'horizon, et la lumière de la queue était faible, mais on devine sa formation normale d'après les notes suivantes: "Febr. 5 (quand β = 6°). The tail proceeded from an arc of the nucleus equal to a sixth of the circumference, and spread out as a fan. . . . The outline throughout the whole length was tolerably well defined."[‡] "The boundary of the tail was exceedingly well marked."[§]

§ 2. Dans mes recherches sur les queues des 33 comètes j'ai montré[‖] que la force répulsive du soleil $1 - \mu$ (suivant la désignation de Bessel) formant la queue, se divise en trois types, dont les valeurs exprimées en unités de la force newtonienne sont: 12 I type, 1 II type et 0·3 III type.

Dans les comètes riches en substances, par exemple dans celles des années 1744 et 1858 V., le second type contient des particules, pour lesquelles $1 - \mu$ varie entre 0·8 et 2·6, et dans ce cas la queue est composée de plusieurs conoïdes qui divergent dans le plan de l'orbite en forme d'éventail. Dans ces queues la bande obscure du milieu ne se voit que près de la tête. Les queues du troisième type sont élargies et très estompées, et cela fait supposer, qu'elles consistent en plusieurs substances semblables entre elles par leurs propriétés chimiques. Dans mes recherches j'ai montré aussi, que la vitesse initiale g de l'émission de la matière vers le soleil est exprimée pour les trois types respectivement par les nombres: 0·15, 0·03 et 0·01, où l'unité de temps est 58·13244 jours et l'unité des distances est le rayon de l'orbite terrestre. Il parait que ces vitesses sont proportionnelles aux racines carrées des forces répulsives; mais les données fournies par l'observation ne sont pas suffisantes pour qu'on s'arrête à cette admission.

La valeur de g se déduit des observations des queues tout à fait développées, dans les têtes desquelles les émissions ont formé déjà du côté du soleil une enveloppe parabolique ou en fer à cheval. Lors de la naissance de la queue et vers son épuisement g doit être naturellement très petit; l'émission enveloppe étroitement le noyau en se recourbant dans la queue et en laissant à l'opposite du soleil un creux très mince.

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[*] Philosophical Transactions; 1822, p. 49.

[†] Astronom. Nachr., B. 64; pp. 109–112.

[‡] Monthly Not.; Eddie; Vol. XL., p. 299.

[§] Ibid.; Gill; p. 301.

[‖] Annales de l'observatoire de Moscou, volumes: III., livr. 1 et 2; IV., livr. 1; V., livr. 1 et 2; VI., livr. 1; VII., livr. 1 et 2 Dans mes citations subséquentes je désignerai nos annales par Ann.

Dans ce cas, surtout si la queue est faible en général, la bande obscure sera invisible ou à peine perceptible. Une construction très simple nous prouvera, que dans tous les cas, où le diamètre du creux intérieur ne surpasse pas le tiers du diamètre de la section extérieure de la queue,—la lumière du milieu ne sera pas au dessous de 0·3 de la lumière des parties les plus claires.

La queue se présentera ainsi comme une bande étroite derrière le noyau.

L'émission du noyau entre dans l'atmosphère de comète, laquelle, comme nous le montrent les comètes télescopiques, ne se répand pas dans la queue et que nous nommerons avec Olbers—*atmosphère ordinaire* (eigenthümlich) pour la distinguer de la partie nébuleuse formée par les effluves de la matière *caudale* (Schweif-Materie).

Cette atmosphère ordinaire enveloppant le noyau et la queue naissante donnera à la comète la forme d'une *bulbe,* elle sera *bulbiforme.*

En s'approchant du soleil la vitesse g croît rapidement, l'effluve de la matière caudale dans l'intérieur de l'atmosphère ordinaire devient plus longue, plus large, plus dense et en se recourbant dans la queue loin du noyau, il entoure ce dernier d'une figure en fer à cheval, dont les bouts prolongés forment les parois du conoïde de la queue.

Le creux du conoïde sera beaucoup plus considérable et la bande obscure plus perceptible (voir Pl. II., fig. 2).

L'atmosphère ordinaire de la comète peut avoir les dimensions plus grandes que celles de l'enveloppe en fer à cheval, et elle peut être visible lors du développement complet de la queue: ". . . . . selten die Repulsivkraft, des Cometen gegen die der Sonne gross genug ist, die Schweif-Materie auch gegen der Sonne zu, noch ausserhalb der eigenthümlichen Atmosphäre des Cometen zu treiben."*

Les enveloppes formées par les émissions abondantes et énergiques peuvent éclipser par leur lumière l'atmosphère ordinaire, ou pousser ses particules hors de la surface limite de niveau des couches atmosphériques.

On a observé souvent l'atmosphère ordinaire autour du sommet parabolique de la queue en forme de *nimbe* semicirculaire ou d'un *halos.*

§ 3. D'après les observations de M. Schmidt, la comète de 1862 III nous présente un bel exemple de la formation de la queue et de son développement avec la conservation de l'atmosphère ordinaire:† "August 13. Das Ansehen des Cometen war zwiebelförmig; Anfang der hufeisenförmigen Basis des Schweifes *mitten in der Coma.* Aug. 15. Figur zwiebelförmig; an der rechten Seite der Rand des Schweifes heller. Aug. 19. Coma und Schweifanfang ganz zwiebelförmig. Aug. 20. Der Schweif erscheint mit doppelten Aesten, die hufeisenförmig *mitten in der Coma* zusammenstossen, und den Kern zum Anfang haben."

Il est intéressant de voir les dessins de Schmidt le 13, 14, 15, 17 et 19 août où la comète est bulbiforme, et en même temps elle a une enveloppe en fer à cheval, qui est entourée de l'atmosphère ordinaire :[*] "... dass die Coma sehr lange Zeit hindurch ihre selbstständige kreisrunde Gestalt behielt, wobei sie links und rechts über die Seitenränder des Schweifes übergriff." ....

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* Olbers; Monatl. Corresp., B. XXV., p. 7.

† Schmidt; Beobachtungen über Cometen; pp. 119–120 et Planches I.–III.

Le passage de la figure bulbiforme en forme parabolique est noté aussi par M. Schmidt dans la comète de 1862 II :[†] "Juni 26. Comet zwiebelförmig. Juli 7. Comet noch zwiebelförmig. Juli 10. Comet parabolisch geformt." M. Tempel a dessiné les premières phases du développement de la queue de la comète de Coggia (1874) ; on voit sur ces dessins,[‡] Pl. VI., que du 20 avril au 3 mai la comète avait la forme d'une simple nébulosité arrondie. Le 16 mai ont paru les premiers indices de la queue. Le 18 on voit la figure bulbiforme avec une petite queue, entourée d'une nébulosité. Le 4 juin s'est formée la figure parabolique, mais encore sans bande obscure ; seulement les contours de la parabole sont plus clairs que l'espace du milieu. Le 3 juillet on voit déjà la tête entièrement développée avec la bande obscure très prononcée.

Sur la même Planche de Tempel nous voyons la comète de 1862 III, le 21 août. Elle y conserve encore la figure bulbiforme, mais sa queue est divisée déjà par la bande obscure et le noyau émet une grande effluve.

Dans les comètes télescopiques le développement de la queue s'arrête souvent à la forme de bulbe. Sous cette forme nous voyons chez M. Tempel[§] les comètes suivantes.

La comète de Thatcher, 1861 I ($q = 0{\cdot}91$), le 5 mai, 29 jours avant le périhélie. A la fin de ce mois elle était "schweiflos" d'après M. Schmidt.

La comète de Respighi, 1863 VI ($q = 0{\cdot}78$), le 5 janvier, 1864, 7 jours après le périhélie.

La comète de 1864 I ($q = 0{\cdot}91$), le 5 août, 10 jours avant le périhélie.

La comète de Henry, 1873 IV. ($q = 0{\cdot}39$), le 3 septembre 1873, 28 jours avant le périhélie. Elle est bulbiforme et la queue s'est détachée même de la tête. Il parait que les émissions se sont épuisées avant le périhélie. En septembre, octobre, et novembre la queue n'est plus mentionnée.

Dans la comète de 1853 IV ($q = 0{\cdot}17$), on n'a pas observé le développement complet ; avant le périhélie (16 octobre), la queue était visible du 30 septembre au 4 octobre et sa longueur montait à 3° sur le dessin de D'Arrest,[||] pour cet intervalle de temps la comète est tout à fait bulbiforme. Après le périhélie on a retrouvé la comète le 27 novembre sans indice de queue.

Vers la disparition de la queue les phases décrites plus haut se succèdent dans l'ordre inverse. Ainsi, sur les dessins de la comète de Halley,[¶] du 25 janvier au 6 février 1836 on voit l'affaiblissement du contour parabolique et en même temps l'apparition d'une queue mince et courte, due aux émissions de petite vitesse g, qui continuent encore à alimenter la queue quelque temps avant la transformation de la comète en une simple nébulosité.

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[*] Schmidt ; Beobachtungen über Cometen, p. 118.

[†] Astron. Nachr., B. 72, p. 123.

[‡] Publicazioni del R. Osserv. di Milano, No. V.

[§] Ibid., Voir les Planches.

[||] Astron. Nachr., B. 37, p. 275.

[¶] Arago : Astron. Popul. T. II., Planches.

§ 4. J'ai montré,[*] que les particules émanées du noyau vers le soleil avec la vitesse initiale (impulsion) g, sous un angle G avec le rayon vecteur, formeront le contour parabolique du sommet de la queue. Le foyer de la parabole sera dans le noyau de la comète, et la condensation de la matière en forme d'enveloppe limitée par la parabole s'explique par l'équation de la courbe sur laquelle se trouvent les particules émises par le noyau à une même époque.

La forme parabolique du sommet de la queue est très évidente dans la grande comète de 1811, d'après les observations d'Olbers.[†]

Si les angles G ne sont qu'aigus ou si g diminue avec l'accroissement de G,—le sommet de la queue ne sera plus parabolique, mais il sera rétréci dans les directions perpendiculaires à l'axe de la queue. Bond a trouvé que le contour du sommet de la queue de la comète de 1858 V, pouvait être représenté par une chaînette.[‡]

Dans la comète de 1860 III le faible contour du sommet de la queue présentait aussi une déviation sensible de la figure d'une parabole. Si le cône d'émission est rempli régulièrement de matière,—le sommet de la queue présentera une distribution régulière de lumière dans son enveloppe parabolique. Mais dans plusieurs comètes, comme on le voit sur les dessins de Schmidt, de Secchi et d'autres, l'effluve consiste en un nombre plus ou moins grand de jets séparés, qui changent continuellement leur intensité, leur nombre et leur grandeur.

La grande comète de 1861 II, nous présente un bel exemple d'une telle division de l'effluve en faisceaux. Schweizer l'a observée à Moscou vers le temps du passage de la terre par le plan de l'orbite cométaire, quand le rayon visuel formait un angle aigu (de 26°) avec le prolongement du rayon vecteur du noyau et quand la seconde queue de la comète était dirigée directement vers la terre. L'effluve émanait du côté du noyau opposé à la terre et ses cinq jets recourbés présentaient dans la lunette la forme d'une corolle à cinq pétales. A cause du changement très rapide de la position relative de la comète et de la terre,—un jour plus tard l'angle du rayon visuel avec le rayon vecteur devint beaucoup plus considérable et la tête de la comète reprit la forme ordinaire.[§]

La comète de 1852 IV nous présente un cas analogue, seulement un peu plus compliqué dans ses détails.

Ces jets séparés, en se répandant dans le conoïde de la queue, doivent y altérer la distribution normale de la lumière.

Dans la comète de 1861 II le prolongement d'un jet se voyait du 8 au 12 juillet comme une bande claire près du milieu de la queue, l'influence de la perspective peut placer quelquefois une bande pareille sur l'axe de la queue. Mon dessin de la comète[||] et les notes de Schmidt nous montrent clairement, que la bande n'était autre chose qu'un jet d'émission recourbé dans la queue :[¶] " Ich hebe ausdrücklich hervor, dass jetzt, wie Juli 1, diese Mittelzone gar nicht mit dem Kerne direct, sondern mit der Lichtströmung des Kerns zusammenhing."

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[*] Astron. Nachr., B. 54, pp. 291–292.

[†] Monatl. Corresp., B. 25, pp. 6 seq.

[‡] G.P. Bond; Astron. Nachr., No. 1339.

[§] Ann., Vol. VII., 2. Observations de la comète de 1861 II.

[||] Ann., VII., 2.

[¶] Beobachtungen über Cometen, p. 82.

Dans la comète de 1863 III[*] ($q = 0{\cdot}63$), le 23 avril deux jours après le périhélie au milieu de la queue, immédiatement derrière le noyau,—on voit une bande courte, claire.

Les formules connues de Bessel,[†] nous indiquent que si le cône d'émission est dirigé justement vers le soleil,—sa matière s'écoule plus abondamment dans la partie antérieure du conoïde, qui est ordinairement plus claire que la partie postérieure.

Quelquefois tout le cône d'émission oscille autour du rayon vecteur, probablement à cause des oscillations du noyau allongé autour de son centre de gravité. Dans ce cas aussi la distribution normale de la lumière sera troublée, et si les oscillations sont grandes, la queue prendra la forme d'un S allongé et le creux intérieur, ainsi que la bande obscure seront détruits.

Les oscillations pareilles ont été très prononcées dans la comète de 1862 II.[‡]

Si les oscillations sont périodiques et de courte durée, elles produisent un entrelacement périodique aussi des parties de la queue. Un entrelacement pareil nous a présenté la comète de 1862 II vers la fin du mois d'août.[§]

Les oscillations plus ou moins périodiques ont été remarquées dans d'autres comètes, quoiqu'elles ne fussent pas assez fortes pour déformer la figure totale de la queue.

§ 5. Dans le paragraphe 2 j'ai parlé de la variation de g avec la variation du rayon vecteur. La formule de Bessel donne pour la distance entre le noyau et le sommet de la queue—

$$\epsilon = \frac{g^2 r^2}{2(1-\mu)}$$

Nous n'avons pas des mesures assez exactes et assez nombreuses de ϵ pour exprimer g en fonction de r. Si on admet que g est inversement proportionnel à r^2, ϵ doit être invariable.

Mais il est probable que g se développe presque subitement, quand à une certaine distance du soleil l'action de ce dernier a commencé à vaincre la force coercitive, pour ainsi dire, du noyau. Il est probable que la diminution de g avant la disparition de la queue s'effectue aussi rapidement.

La comète de 1853 III, d'après les observations de Schmidt,[‖] semble parler en faveur de la constance de ϵ pendant une grande diminution de r. Dans la comète de 1858 V[¶] on voit une grande diminution de la nébulosité du 2 au 12 septembre.

Du 24 septembre au 13 octobre la nébulosité reste invariable, mais on doit ajouter que vers le 15 septembre ont paru les émissions du noyau.

Les mesures des nébulosités des comètes des années: 1860 III, 1862 II, 1862 III et 1861 II n'accusent pas l'accroissement de leurs nébulosités avec l'éloignement du soleil, et pourtant dans la dernière comète le rayon vecteur est devenu trois fois plus grand durant les mesures.[**]

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[*] Tempel; loco cit. Tav. VII., fig. V.

[†] Ann. III., 1; pp. 43–44.

[‡] Ibid.; pp. 9–45.

[§] Ibid.; pp. 10, 11, 45.

[‖] Astr. Nachr., No. 883.

[¶] Pulkovaer Beobacht. des grossen Cometen von 1858.

[**] Schmidt; Beobacht. über Cometen,

D'après les recherches théorétiques de M. Roche,* la surface limite des couches de niveau de l'atmosphère (ordinaire) varie dans ses dimensions proportionnellement au rayon vecteur. Si la surface effective de l'atmosphère atteint la surface limite, elle doit varier dans ses dimensions dans le dit rapport; c'est pourquoi dans les comètes télescopiques on peut attendre la variation du rayon de la nébulosité avec la variation du rayon vecteur. Dans la comète d'Encke on a observé la diminution de la nébulosité: en 1828, du 28 octobre au 24 décembre, son diamètre a subi un changement de 68000 à 3000 lieues, tandis que le rayon vecteur a varié entre 1·46 et 0·54. En 1838, du 9 octobre au 17 décembre la variation du diamètre de la nébulosité entre 61000 et 650 lieues correspond à la variation du rayon vecteur entre 1·42 et 0·34.

Maedler attribue cette différence des diamètres à l'influence du crépuscule. Pour déterminer la valeur de g il ne faut mesurer que les enveloppes formées par les effluves, et si on ne les distingue pas des atmosphères ordinaires, on court le risque de brouiller les résultats des différentes causes.

Quand g est petit, la formation de la queue et des enveloppes adjacentes au noyau ressemble à l'écoulement de l'atmosphère, soumise à la répulsion du soleil, étudié par M. Roche et représenté par la fig. 1 (Pl. II). En imaginant encore autour de cette figure l'atmosphère ordinaire, on aura la figure bulbiforme de la comète.

§ 6. Les queues normales sont situées toujours dans l'angle formé par le prolongement du rayon vecteur (l'axe ξ) et la ligne perpendiculaire à ξ, passant par le noyau et prise positivement vers la région que la comète vient de quitter (l'axe η).

Dans quelques comètes on a remarqué des appendices situés à l'opposite de ces queues. Ainsi la comète de 1862 II ($q = 0·96$), avait avant le périhélie une queue secondaire, longue de 0·06 (l'unité est la distance terre—soleil), située dans l'angle formé par les directions négatives des ξ et η et faisant l'angle de 64° avec le rayon vecteur.

Pour sa formation on devrait admettre la force attractive un peu plus grande que l'attraction newtonienne; mais j'ai montré† qu'il suffit pour elle l'attraction ordinaire et l'impulsion du noyau ou la vitesse initiale $g = 0·02$. Les émissions appartenant à la queue normale entrainent avec elles les particules de la substance planétaire, pour ainsi dire, de la comète dans la direction vers le soleil, en leur communiquant une impulsion dans cette direction. J'entends par substance planétaire les particules ou les corpuscules de la comète ou de son atmosphère qui par leur densité sont insensibles, ou presque insensibles, à l'action de cette énergie qui se manifeste dans la force qui anime la substance extrêmement raréfiée et volatile de la queue normale. A cause de l'impulsion reçue, les corpuscules de la queue anomale doivent devancer le noyau de la comète et raccourcir leurs rayons vecteurs.

La comète de 1844 III‡ ($q = 0·25$; après le périhélie), présente aussi une queue anomale très courte, qu'on n'a pas mesurée. Elle se trouvait aussi dans l'angle des

* Annales de l'observ. de Paris; Vol. V.

† Ann. III., 1; pp. 39–40.

‡ Ann. V., 2; p. 65.

ξ et η négatifs et faisait avec le rayon vecteur l'angle de 41°. L'explication précédente s'applique à cet appendice.

Dans la comète de 1823* ($q = 0{\cdot}23$; après le périhélie) un pareil appendice était long de 0·12, et formait avec le rayon vecteur l'angle de 20°. Comme l'angle de la tangente avec le rayon vecteur était de 25°, on voit que la queue anomale se trainait derrière le noyau en faisant avec la queue normale l'angle de 146°.

Ses particules décrivaient la même orbite que le noyau et elles ne demandent ni une augmentation, ni une diminution de la force newtonienne ; donc il faut admettre, que l'appendice anomal n'était autre chose que la comète elle-même allongée dans son orbite ; sa partie précédente était plus dense et avait la queue (normale).

Dans la comète de 1877 II (q=0·95 ; après le périhélie), la queue secondaire, longue de 0·006 faisait un angle plus de 70° avec la queue normale† et l'angle de 30° seulement avec la tangente. Elle était produite par la force $1 - \mu$ très petite du troisième type, ou peut-être elle était aussi la partie postérieure de la comète allongée dans l'orbite.

La comète de 1851 (Brorsen ; $q = 0{\cdot}14$; après le périhélie), a été vue‡ avec un appendice directement opposé à la queue normale ; mais la terre était alors près du plan de l'orbite, et par cette raison il est impossible de déterminer l'angle de l'appendice avec le rayon vecteur et la mode de sa formation.

Les comètes de 1577 ($q = 0{\cdot}18$; après le périhélie§) et de 1680 ($q = 0{\cdot}01$; après le périhélie‖) ont eu aussi des petits appendices faibles. Faute des mesures de leurs positions on ne peut pas décider s'ils étaient les queues anomales, pareilles à l'appendice de la comète de 1862 II, ou les allongements des comètes, comme celui de la comète de 1823.

§ 7. Pour rendre plus claires les différences dans les figures et les positions des queues, produites par les différents types de la force répulsive $1 - \mu$, je veux construire les queues d'une comète imaginaire, dont la distance périhélie est $q = 0{\cdot}25$.

Cette comète ressemble beaucoup, entr'autres à la comète de 1744, dont la distance périhélie est 0·22. Je calcule les positions des points de l'axe de la queue pour les moments correspondant aux anomalies vraies du noyau : $v = -130°$, $-110°$, $0°$, $+110°$ et $+130°$.

Les forces répulsives $1 - \mu$ soient : pour le premier type 12 ; pour le second 2·6, 1·0 et 0·8 et pour le troisième 0·3. On verra plus loin que la variété des valeurs de la force pour le second type n'est pas arbitraire. Ayant construit les axes pour ces trois valeurs du second type, on pourra porter sur la planche les axes pour les valeurs intermédiaires.

Pour les queues qui correspondent à l'anomalie du noyau $-130°$ je prends les particules séparées du noyau, sans vitesse g, aux moments des anomalies $-140°$ et $-150°$.

* Ann. V. 2; p. 59.

† Ann. V., 1; pp. 77–78.

‡ Astron. Nachr., Nos. 780, 782.

§ Hevel; Cometographia; p. 454.

‖ Astron. Nachr., No. 192.

Pour les queues à l'anomalie du noyau — 110° sont prises les particules émises aux anomalies — 120° et — 130°.

Pour les queues au périhélie du noyau, je prends les particules séparées du noyau aux anomalies — 50°, — 70°, et — 90°.

Pour les queues à l'anomalie + 110° sont prises les particules émises aux anomalies + 100° et + 90° et enfin pour les queues à l'anomalie + 130° sont prises les particules émises du noyau aux moments de ses anomalies + 120° et + 110°.

Le temps est compté du moment du périhélie et il est exprimé en jours.

Les calculs sont effectués à l'aide des formules exactes du mouvement hyperbolique, qui sont :*

1. Pour l'orbite convexe vers le soleil (μ est une répulsion):

$$E^2 = m \cdot \sin^2 \beta \, (m + 2) + 1 \qquad P = 2r_1 \cdot E \cdot \sin \tfrac{1}{2}(\psi + V_1) \cdot \sin \tfrac{1}{2}(\psi - V_1)$$

$$\cos V_1 = \frac{m \cdot \sin^2 \beta + 1}{E} \qquad b = P \cdot \cot^2 \psi$$

$$N = \lambda E \cdot \tan F + \log \tan(45^\circ + \tfrac{1}{2}F) = \frac{\lambda K t}{b^{\frac{3}{2}}}$$

$$\tan \tfrac{1}{2}V = \tan \tfrac{1}{2}F \cdot \tan \tfrac{1}{2}\psi$$

$$R = \frac{P}{2E \cdot \sin \tfrac{1}{2}(\psi + V) \cdot \sin \tfrac{1}{2}(\psi - V)}$$

2. Pour l'orbite concave vers le soleil (μ est l'attraction newtonienne affaiblie) :

$$E^2 = m \cdot \sin^2 \beta \, (m - 2) + 1 \qquad P = 2r_1 \cdot E \cdot \cos \tfrac{1}{2}(\psi + V_1) \cdot \cos \tfrac{1}{2}(\psi - V_1)$$

$$\cos V_1 = \frac{m \cdot \sin^2 \beta - 1}{E} \qquad b = P \cdot \cot^2 \psi$$

$$N = \lambda E \cdot \tan F - \log \tan(45^\circ + \tfrac{1}{2}F) = \frac{\lambda K t}{b^{\frac{3}{2}}}$$

$$\tan \tfrac{1}{2}V = \tan \tfrac{1}{2}F \cdot \cot \tfrac{1}{2}\psi$$

$$R = \frac{P}{2E \cdot \cos \tfrac{1}{2}(V + \psi) \cdot \cos \tfrac{1}{2}(V - \psi)}$$

$$\log k = 8{\cdot}2355814 - 10 \, ; \; \log \lambda = 9{\cdot}6377843 - 10$$

N a le signe de t; F est toujours positif ; quand V est négatif ψ le doit être de même.

Les coordonnées des particules rapportées aux axes ξ et η seront :

$$\Delta^2 = r^2 + R^2 - 2rR \cdot \cos(v - \omega) \, ; \qquad \eta = R \cdot \sin(v - \omega)$$

$$\frac{\eta}{\Delta} = \sin \phi \qquad \xi = \Delta \cdot \cos \phi$$

Quand la force effective du soleil $\mu = 0$, c'est à dire quand la particule se meut dans la direction de la tangente avec la vitesse du noyau dans le moment de l'émission, alors en désignant par s la partie de la tangente entre le point de l'émission et l'axe de la queue et par τ l'intervalle $(M - M_1) \cdot k = (M - M_1) \div 58 \cdot 13244$, on a :

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* Ann. V., 2 ; pp. 32 et seq.

$$s^2 = \frac{\tau^2 \cdot 2}{r_1} \qquad R^2 = s^2 + r_1^2 + 2sr_1 \cos \beta$$

$$\sin \alpha = \frac{s \cdot \sin \beta}{R} \qquad \omega = v_1 + \alpha$$

où α est l'angle entre r_1 et R.

Si $r > R \cos(v - \omega)$, ξ est négatif et ϕ est obtus.—

Dans ces formules les lettres désignent :

M, v et r—le temps de l'observation de la queue, l'anomalie du noyau et son rayon vecteur.—

M_1, v_1 et r_1—le temps d'émission, l'anomalie vraie et le rayon vecteur du noyau pour ce temps.— Les anomalies sont comptées négatives avant le périhélie du noyau.—

β—l'angle du rayon vecteur avec la tangente.—

H—la vitesse du noyau (pour l'unité de temps égale à 58·13244 jours) dans la direction de la tangente pour le temps M_1.—

μ—l'accélération effective du soleil sur la particule, à la distance $= 1$.—

$K = k\sqrt{\mu}$, où k est le nombre de Gauss.

V_1—l'angle entre le rayon r_1 et l'axe de l'orbite hyperbolique de la particule ; cet angle est négatif avant le passage du noyau par le périhélie, car dans ce cas la particule s'approche du soleil pendant quelque temps après être émise du noyau.—

J—l'intervalle de temps entre l'émission de la particule du noyau et son passage par le périhélie hyperbolique ; J est positif ou négatif selon le signe de V_1.—

π—le temps du passage de la particule par le périhélie hyperbolique ; il est égal à $M_1 - J$.—

t—l'intervalle de temps entre le passage du périhélie hyperbolique et le temps de l'observation M ; il est égal à $M - \pi$.—

E—l'excentricité de l'orbite hyperbolique.—

ψ—l'angle asymptotique de l'hyperbole, dont le cosinus est $1 \div E$.—

V—l'anomalie vraie hyperbolique de la particule pour le temps M.—

R—le rayon vecteur hyperbolique de la particule.—

ω—l'angle entre le rayon R et l'axe de l'orbite parabolique du noyau. Il est clair que—

$$\omega = v_1 - V_1 + V \text{ et } v - \omega = \text{l'angle } (R, r)$$

$$H^2 = \frac{2}{r_1}; \ \beta = 90^\circ - \frac{v_1}{2} \text{ et } m = \frac{H^2 r_1}{\mu}.$$

L'angle β est obtus avant le périhélie du noyau et aigu après ce périhélie.

ϕ est l'angle de la ligne menée du noyau à la particule avec le prolongement du rayon vecteur.

Si on veut prendre en considération la vitesse initiale d'émission g, faisant un angle G avec le rayon vecteur (G est pris positif quand l'émission est derrière le rayon vecteur) ; on doit corriger un peu les valeurs de β et de H^2.

On aura :

$$H_1^2 = H^2 + g^2 - 2Hg \cos (\beta - G)$$

$$\sin \gamma = \frac{g}{H_1} \sin(\beta - G) ; \ \beta_1 = \beta + \gamma.$$

Ces H_1 et β_1 doivent être pris partout au lieu de H et β, et on aura aussi—

$$m = \frac{H_1^2 \cdot r^1}{\mu}.$$

§ 8.—Les résultats des calculs sont présentés par les nombres suivants, que je donne en détails, car le calcul de l'angle F est assez pénible.

L'anom. vraie.	Log du rayon vect.	Temps.	β.
— 160°	0·9185996	— 683·1167	170°
150	0·5719476	216·4117	165
140	0·3298366	99·2780	160
130	0·1460434	55·8214	155
120	0·0000000	35·5987	150
110	9·8807574	24·6543	145
90	9·6989700	13·7019	135
70	9·5712110	8·3716	125
— 50	9·4833886	— 5·1393	115
0	9·3979400	0·0000	90
+ 90	9·6989700	+ 13·7019	45
100	9·7818050	18·0450	40
110	9·8807574	24·6543	35
120	0·0000000	35·5987	30
+ 130	0·1460434	+ 55·8214	25

1. $1 - \mu = 12$ $\log m = 9·2596373$ $\log K = 8·7562778$

M	— 55·8214		+ 55·8214	
v	— 130°		+ 130°	
M_1	— 99·2780	— 216·4117	35·5987	24·6543
v_1	— 140°	— 150°	+ 120°	+ 110°
$\log E$	0·0098497	0·0056949	0·0205330	0·0266371
V_1	— 3° 16′ 28″	— 2° 34′ 14″	4° 18′ 22″	4° 36′ 32″
ψ	12 9 24	9 15 30	17 28 48	19 51 46
$\log P$	8·657585	8·657567	8·657585	8·657577
$\log b$	9·991029	0·233140	9·661198	9·541937
J	— 19·4075	— 46·1634	5·6816	3·5451
t	24·0491	114·4269	25·9042	34·7122
N	0·614635	1·267302	2·068410	4·184446
F	35° 57′ 15″	58° 29′ 21″	70° 41′ 13″	81° 25′ 4″
V	3 57 28	5 11 29	12 26 20	17 8 4
$\log R$	0·345844	0·701271	0·280941	0·451761
(r, R)	2° 46′·1	12° 14′·3	1° 52′·0	7° 28′·5
ϕ	7 29·1	16 52·5	6 58·2	14 40·3
Δ	0·82211	3·67070	0·51265	1·45346

M	— 24·6543		+ 24·6543	
v	— 110°		+ 110°	
M_1	— 35·5987	— 55·8214	18·0450	13·7019
v_1	— 120°	— 130°	+ 100°	+ 90°
$\log E$	0·0205330	0·0148648	0·0329586	0·0392913
V_1	— 4° 18′ 22″	— 3° 51′ 30″	4° 45′ 33″	4° 45′ 50″
ψ	17 28 48	14 54 20	22 2 26	24 0 22
$\log P$	8·657575	8·657594	8·657581	8·657566
$\log b$	8·983564	9·421696	8·328979	8·080452
J	— 5·6815	— 9·8857	2·3444	1·6187
t	5·2629	21·2814	8·9537	12·5711
N	0·420247	1·026158	1·519061	2·839290
F	25° 40′ 8″	51° 37′ 52″	62° 38′ 20″	76° 7′ 26″
V	4 0 43	7 14 31	13 30 58	18 54 15
$\log R$	9·996295	0·233265	9·967691	0·105593
(r, R)	1° 40′·9	8° 54′·0	1° 14′·6	5° 51′·6
ϕ	7 10·5	15 52·8	6 49·7	14 21·4
Δ	0·23300	0·96748	0·16938	0·52508

M		0	
v		0°	
M_1	— 5·1393	— 8·3716	— 13·7019
v_1	— 50°	— 70°	— 90°
$\log E$	0·0612459	0·0512488	0·0392913
V_1	— 3° 28′ 4″	— 4° 21′ 14″	— 4° 45′ 50″
ψ	29 43 8	27 17 26	24 0 23
$\log P$	8·657569	8·657584	8·657556
$\log b$	9·144560	9·232403	9·360140
J	— 0·4524	— 0·8374	— 1·6186
t	4·6869	7·5342	12·0833
N	2·228989	2·645416	2·729217
F	71° 0′ 3″	74° 36′ 54″	75° 28′ 19′
V	21 26 1	20 57 39	18 41 14
$\log R$	9·801321	9·951847	0·089617
(r, R)	25° 5′·9	44° 41′·1	66° 32′·9
ϕ	39 43 ·2	58 27 ·3	78 1 ·5
Δ	0·42009	0·73853	1·15274

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2. $1 - \mu = 2·6$ $\log m = 0·0969100$ $\log K = 8·3376414$

M	— 24·6543		+ 24·6543	
v	— 110°		+ 110°	
M_1	— 35·5987	— 55·8214	18·0450	13·7019
v_1	— 120°	— 130°	+ 100°	+ 90°
$\log E$	0·1522049	0·1184686	0·2139481	0·2408109
V_1	— 22° 24′ 39″	— 21° 22′ 30″	4° 45′ 33″	4° 45′ 50″
ψ	45 13 20	40 25 29	22 5 20	21 2 15
$\log P$	9·494849	9·494851	9·494850	9·494850
$\log b$	9·488115	9·634161	9·269922	9·187087
J	— 21·8080	— 38·4395	8·8043	6·0244
t	— 10·8636	— 7·2724	15·4136	16·9768
N	— 0·601487	— 0·243143	1·813207	2·658592
F	30° 18′ 0″	13° 39′ 27″	60° 9′ 22″	68° 38′ 46″
V	—12 52 4	—5 2 57	31 46 18	39 5 21
$\log R$	9·910435	0·005569	9·902255	9·949121
(r, R)	0° 27′·4	3° 40′·4	0° 19′·2	1° 56′·9
ϕ	6 53 ·1	14 30 ·1	6 35·2	13 11 ·2
Δ	0·05411	0·25918	0·03881	0·13260

M		0	
v		0°	
M_1	— 5·1393	— 8·3716	— 13·7019
v_1	— 50°	— 70°	— 90°
$\log E$	0·3185903	0·2856202	0·2408109
V_1	— 13° 17′ 29″	— 17° 42′ 49″	— 21° 2′ 16″
ψ	61 18 9	58 47 52	54 56 41
$\log P$	9·494850	9·494851	9·494849
$\log b$	8·971505	9·059328	9·187085
J	— 1·6467	— 3·0752	— 6·0245
t	3·4926	5·2964	7·6772
N	1·151641	1·289482	1·202300
F	41° 38′ 2″	46° 40′ 1″	46° 39′ 55″
V	25 23 41	27 19 18	25 16 55
$\log R$	9·549725	9·640577	9·735722
(r, R)	11° 18′·8	24° 57′·9	43° 40′·8
ϕ	35 27·5	51 35·7	69 5·8
Δ	0·11990	0·23542	0·40229

3. $1 - \mu = 1$

M	— 24·6543		+ 24·6543	
v	— 110°		+ 110°	
M_1	— 35·5987	— 55·8214	18·0450	13·7019
v_1	— 120°	— 130°	+ 100°	+ 90°
$\log s$	9·4252884	9·8067711	9·3153494	9·5761207
a	9° 49′0	18° 18′·1	9° 52′·4	19° 10′·2
$\log R$	9·892570	9·935773	9·889240	9·909255
(r, R)	0° 11′·0	1° 41′·9	0° 7′·6	0° 49′·8
ϕ	6 49·4	14 2·4	6 31·7	12 52·6
Δ	0·02110	0·10540	0·01510	0·05278

M		0	
v		0°	
M_1	— 5·1393	— 8·3716	— 13·7019
v_1	— 50°	— 70°	— 90°
$\log s$	9·3553061	9·2532994	9·6733922
a	44° 33′ 30″	56° 27′ 25″	63° 26′ 4″
$\log R$	9·466470	9·515773	9·571334
(r, R)	5° 26′·5	13° 32′·6	26° 33′·9
ϕ	33 50·0	48 8·4	63 26·3
Δ	0·04986	0·10311	0·18634

4. $1 - \mu = 0·8$ $\log m = 1·0000000$ $\log K = 7·5238807$

M	— 24·6543	0	+ 24·6543
v	— 110°	0°	+ 110°
M_1	— 55·8214	— 13·7019	13·7019
v_1	— 130°	— 90°	+ 90°
$\log E$	0·5921811	0·8063920	0·8063920
V_1	— 78° 24′ 9″	— 51° 20′ 25″	51° 20′ 25″
ψ	75 10 55	81 0 54	81 0 54
$\log P$	0·397940	0·397940	0·397940
$\log b$	9·242956	8·795881	8·795881
J	— 63·0773	— 11·0732	11·0732
t	— 31·9102	2·6287	22·0256
N	— 1·456722	0·562083	4·709633
F	47° 45′ 17″	13° 26′ 54″	62° 24′ 2″
V	— 59 47 45	15 42 55	70 40 0
$\log R$	9·925611	9·542798	9·903807
(r, R)	1° 23′·6	22° 56′·7	0° 40′·4
ϕ	13 57·5	62 19·1	12 49·7
Δ	0·08494	0·15363	0·04243

5. $1 - \mu = 0·3$ $\log m = 0·4559320$ $\log K = 8·1581304$

M	— 24·6543	0	+ 24·6543
v	— 110°	0°	+ 110°
M_1	— 55·8214	— 13·7019	13·7019
v_1	— 130°	— 90°	+ 90°
$\log E$	— 0·0787893	0·1736153	0·1736153
V_1	— 114° 6′ 27″	— 73° 18′ 3″	73° 18′ 3″
ψ	33 28 45	47 53 46	47 53 46
$\log P$	9·853872	9·853872	9·853872
$\log b$	0·212990	9·765916	9·765916
J	— 59·9217	— 12·9980	12·9980
t	— 28·7546	0·7039	23·9504
N	— 0·086127	0·0098753	0·336011
F	36° 8′ 47″	2° 38′ 50″	50° 11′ 30″
V	— 94 40 7	5 57 21	93 2 20
$\log R$	9·898465	9·458821	9·889644
(r, R)	0° 33′·7	10° 44′·6	0° 15′·7
ϕ	13 47·4	58 43·0	12 43·6
Δ	0·03253	0·06274	0·01609

Ces dessins donnent une idée claire de la position relative des queues des différents types pour l'orbite à dimension donnée et pour les moments symétriquement disposés autour du périhélie et assez éloignés de lui.

On voit que dans ces positions les observations ne peuvent pas discerner non seulement les variétés d'un type, mais les types eux-mêmes, tellement les queues sont rapprochées les unes des autres. La longueur de la queue est ici le seul critérium, car elle est presque proportionnelle à la force $1 - \mu$.

On voit de plus, que si les substances du 1 et du 2 type sont émises en même temps et en même quantité,—la queue du premier type sera beaucoup plus faible, car ces particules sont *distendues* sur une longueur plus grande. L'affaiblissement de lumière à partir du noyau vers la fin de la queue suivra ici une progression plus rapide.

Les coordonnées des points des queues pour l'anomalie $v = 0$, c'est à dire pour le périhélie sont données sur la planche III, fig. 5, où l'échelle est 1 = 600 millimètres, et où on trouve les mêmes désignations. Pour le premier type sont prises seulement les particules émises par le noyau à son anomalie $v = -50°$; celles qui sont émises plus-tôt, se sont trop éloignées du noyau. Pour les autres types le moment d'émission s'étend jusqu'à l'anomalie $-90°$.

Dans le second type, les conoïdes correspondant aux forces mineures sont plus courts, mais la *distension*, proportionnelle aux forces, tâche à les égaler en réalité, et c'est pourquoi nous les avons prolongés. Dans l'intervalle des conoïdes des forces 2·6 et 1·0 nous avons interposé encore quatre conoïdes *c*, *d*, *e*, *f* correspondant aux forces 2·2, 1·8, 1·5 et 1·2.

La queue du troisième type, qui est toujours estompée et dilatée contient probablement plusieurs variétés de $1 - \mu$; mais sur notre dessin elle est laissée non composée.

Il est aisé de voir, que vers le périhélie non seulement les types, mais leurs variétés peuvent se distinguer; dans les pareilles conditions ont été observées les comètes de 1744, 1811, et 1858 V.

Dans les queues du premier type (hydrogène) on ne remarque pas la complexité produite par la *juxtaposition* de plusieurs conoïdes. La comète de 1811, par exemple, consistait en un seul conoïde, divisé d'un bout à l'autre par une bande obscure. Dans les queues faibles de ce type le bord postérieur devient quelquefois invisible par sa faiblesse, par exemple dans la comète de 1744.

Les queues du second type (hydrocarbures) sont souvent aussi simples, et j'ai montré* que pour ces queues la force $1 - \mu$ ne diffère pas sensiblement de *l'unité.* Mais il y a des comètes,—par exemple celles de 1744 et 1858 V—où les queues du second type ont été *composées.* Dans ces deux comètes la force $1 - \mu$ présentait les différentes valeurs entre 0·8 et 2·6. Cela provient probablement de la diversité des substances de ces comètes, de la variété de leurs hydrocarbures.

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* Ann. III., 1 et 2; IV., 1; V., 1 et 2; VI., 1; VII., 1.

C'est en me fondant sur ces données numériques, que j'ai choisi les nombres pour la construction de la queue du 2 type de notre comète théorétique.

Les queues du troisième type (substances aux poids atomiques très considérables)[*] semblent pour la plupart être composées, mais elles sont toujours si faibles et si courtes que, même dans des conditions les plus favorables, les observations n'y conduisent qu'aux réflexions générales.

On voit d'après la fig. 5, que les creux de différents conoïdes doivent coïncider près de la tête; plus loin les intersections des conoïdes détruisent la bande obscure et donnent des raies claires, qui convergent à quelque distance de la tête.

Encore plus loin les conoïdes doivent s'écarter, et chacun d'eux présentera ses bords clairs et sa bande obscure.

Dans les queues composées faibles de lumière,—par exemple dans la comète de 1807,—la bande obscure peut devenir imperceptible même près de la tête.

On n'a qu'à jeter un regard sur les excellents dessins de la comète de 1858 V faits par M. Winnecke,[†] pour remarquer leur ressemblance frappante avec notre fig. 5. Le 19 et le 30 septembre on voit aussi la queue du premier type, et la figure du 9 octobre montre des raies claires, qui convergent près de l'étoile α Coronæ, sur les autres planches on voit la bande obscure près du noyau, où plusieurs conoïdes sont placés l'un dans l'autre.

Sur le dessin de Harvard College,[‡] du 5 octobre, l'on voit même les deux bords du conoïde du premier type.

Dans l'extrémité de la queue du second type de la comète de 1744 les conoïdes se sont déjà tellement écartés, que Chéseaux a vu chacun d'eux séparément:[§] "leurs bords étaient assez distincts et rectilignes. . . . Février 27, 28 et 29 . . . chacun d'eux (5 grands rayons ou queues) était composé de trois bandes: celle du milieu était plus obscure et le double plus large que celles des bords. L'entre-deux des rayons était sombre comme le reste du ciel."

La prédominence de la largeur de la queue dans le plan de l'orbite,—bien constatée pour la comète de 1858 V par Pape, Winnecke et les autres observateurs,—est la conséquence nécessaire de la juxtaposition de plusieurs conoïdes, inégalement courbés et déviés l'un de l'autre dans le plan de l'orbite.

Il faut remarquer, que l'étude des parties de la queue voisines de la tête peut être facilitée par les formules connues de Bessel; mais pour les parties éloignées ces formules sont très inexactes (voir: Ann. V., 2; pp. 43–44).

J'ose croire que chacun, qui lira attentivement mes recherches sur les queues des comètes avec leurs derniers résultats, sera persuadé que la position d'une queue, sa forme, sa courbure et sa structure—s'expliquent par la force répulsive du soleil, du tel ou tel des trois types soumise à la loi de Newton, et par l'effluve de matière cométaire du noyau vers le soleil avec une certaine vitesse initiale, ou une répulsion.

Observatoire de Moscou, Mars 1881.

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[*] Ann. VI., 1; pp. 59–61.

[†] Pulkovaer Beobachtungen des grossen Cometen von 1858; Tab. I. et seq.

[‡] Annals of Harvard College Observatory; Vol. VIII.

[§] Chéseaux; Traité de la comète qui a paru en décembre 1743.

ON THE DETERMINATION OF THE ERROR AND RATE OF A CLOCK BY THE METHOD OF LEAST SQUARES.

By ORMOND STONE.

I.

The equations of condition, reduced to equal weight, are of the form—

$$\frac{x + y\,(t_1 - t_0) - u_1}{\varepsilon_1^2} = 0$$

where x and y are the error and rate at the time t_0, u_1 the observed error at the time t_1, and ε_1 is the probable error.

The clock will be assumed to be completely compensated, and therefore only subject to accidental changes in error and rate. It will also be assumed that the accidental changes in error and rate are independent of one another. Let β be the probable change in error, and γ the probable change in rate to which the clock is liable at any given instant t_0; then by the theory of least squares, the square of the probable change in error arising therefrom will be—

$$\varepsilon'^2 = \beta^2 + \gamma^2\,(t_1 - t_0)^2$$

at the time t_1. The term *probable change* is here used in a sense entirely analogous with that usually given the term *probable error.*

As the clock is liable to similar changes at each instant, we shall have for the whole probable accidental change at the time t_1—

$$\varepsilon^2 = \int_{t_0}^{t_1} [\beta^2 + \gamma^2\,(t_1 - t_0)^2]\,dt;$$

whence, if α be the probable error of observation, and together with β and γ be assumed constant, we have—

$$\varepsilon_1^2 = \alpha^2 + \beta^2\,(t_1 - t_0) + \tfrac{1}{3}\gamma^2\,(t_1 - t_0)^3.$$

II.

Putting $\alpha^2 = \xi$, $\beta^2 = \eta$, $\frac{1}{3}\gamma^2 = \zeta$ and $t_0 = 0$, the equations of condition assume the form—

$$\frac{\Delta}{q} = \frac{x + yt - u}{\xi + \eta\tau + \zeta\tau^3} = 0$$

in which τ is essentially positive and numerically equal to t.

The normal equations for x and y may be readily obtained in the usual manner. For the determination of ξ, η and ζ, the theory of least squares gives—

$$\Sigma\,\delta = \Sigma\left(\frac{\Delta^2}{q} - c\right) = 0.$$

For the most probable values of $q = \xi + \eta\tau + \zeta\tau^3$, we have—

$$\Sigma\,\phi'\delta\cdot\frac{d\delta}{dq} = 0$$

where $\phi'\delta$ is some function of δ; whence by indeterminate coefficients—

$$c'\cdot\phi'\delta\cdot\frac{d\delta}{dq} = \delta = \frac{\Delta^2}{q} - c,$$

where c' is an unknown constant and for the most probable values of ξ, η and ζ—

$$c' \Sigma \phi' \delta \cdot \frac{d\delta}{d\xi} = \Sigma \left(\frac{\Delta^2}{q} - c \right) \frac{dq}{d\xi} = 0,$$

$$c' \Sigma \phi' \delta \cdot \frac{d\delta}{d\eta} = \Sigma \left(\frac{\Delta^2}{q} - c \right) \frac{dq}{d\eta} = 0,$$

$$c' \Sigma \phi' \delta \cdot \frac{d\delta}{d\zeta} = \Sigma \left(\frac{\Delta^2}{q} - c \right) \frac{dq}{d\zeta} = 0.$$

The normal equations for the determination of the five unknown quantities are, therefore—

$$\Sigma \frac{x + yt - u}{\xi + \eta\tau + \zeta\tau^3} = 0,$$

$$\Sigma \frac{(x + yt - u)t}{\xi + \eta\tau + \zeta\tau^3} = 0,$$

$$\Sigma \frac{(x + yt - u)^2}{\xi + \eta\tau + \zeta\tau^3} - \Sigma c = 0,$$

$$\Sigma \frac{(x + yt - u)^2 \tau}{\xi + \eta\tau + \zeta\tau^3} - \Sigma c\tau = 0,$$

$$\Sigma \frac{(x + yt - u)^2 \tau^3}{\xi + \eta\tau + \zeta\tau^3} - \Sigma c\tau^3 = 0.$$

These equations are not linear in form, but if approximate values of the unknown quantities be given, may be readily made so by simple differentiation. If Δ_0, q_0, x_0, &c., be approximate values of Δ, q, x, &c., putting $\delta\Delta = \Delta - \Delta_0$, &c., and neglecting terms of a higher order than the first, we have for a new set of normal equations—

$$\Sigma \frac{1}{q_0} \left(\delta\Delta - \frac{\Delta_0}{q_0} \cdot \delta q \right) = 0,$$

$$\Sigma \frac{t}{q_0} \left(\delta\Delta - \frac{\Delta_0}{q_0} \cdot \delta q \right) = 0,$$

$$\Sigma \frac{\Delta_0}{q_0} \left(2\delta\Delta - \frac{\Delta_0}{q_0} \cdot \delta q \right) = 0,$$

$$\Sigma \frac{\Delta_0 \tau}{q_0} \left(2\delta\Delta - \frac{\Delta_0}{q_0} \cdot \delta q \right) = 0,$$

$$\Sigma \frac{\Delta_0 \tau^3}{q_0} \left(2\delta\Delta - \frac{\Delta_0}{q_0} \cdot \delta q \right) = 0;$$

where—

$$\delta\Delta = \frac{d\Delta}{dx} \cdot \delta x + \frac{d\Delta}{dy} \cdot \delta y,$$

$$\delta q = \frac{dq}{d\xi} \cdot \delta\xi + \frac{dq}{d\eta} \cdot \delta\eta + \frac{dq}{d\zeta} \cdot \delta\zeta.$$

III.

If we compare the value of x derived from any two successive observations with an approximate value x_0, we shall obtain a residual—

$$u_1 \frac{t_2}{t_2 - t_1} - u_2 \frac{t_1}{t_2 - t_1} - x_0 = d, \qquad (1.)$$

with a probable error whose square is—

$$\varepsilon_{12}^2 = \kappa + \frac{t_1^2 + t_2^2}{(t_2 - t_1)^2} \cdot \xi + \frac{t_1 t_2 (\tau_1 + \tau_2)}{(t_2 - t_1)^2} \cdot \eta + \frac{t_1^2 t_2^2 (\tau_1 + \tau_2)}{(t_2 - t_1)^2} \cdot \zeta,$$

where κ is the probable error of x_0, and $t_0 = 0$ is assumed either greater or less than both t_1 and t_2. If t_0 lie between t_1 and t_2, we shall have—

$$u_1 \frac{\tau_2}{\tau_1 + \tau_2} + u_2 \frac{\tau_1}{\tau_1 + \tau_2} - x_0 = d, \qquad (1a.)$$

and—

$$\varepsilon_{12}^2 = \kappa + \frac{\tau_1^2 + \tau_2^2}{(\tau_1 + \tau_2)^2} \cdot \xi + \frac{\tau_1 \tau_2}{\tau_1 + \tau_2} \cdot \eta + \frac{\tau_1^2 \tau_2^2}{\tau_1 + \tau_2} \cdot \zeta.$$

If we put $\varepsilon^2 = \kappa + i\xi + j\eta + k\zeta$, we shall have for the determination of κ, ξ, η and ζ, equations of the form—

$$\begin{aligned} \kappa + i_1 \xi + j_1 \eta + k_1 \zeta - (0{\cdot}6745\, d_1)^2 &= 0, \\ \kappa + i_2 \xi + j_2 \eta + k_2 \zeta - (0{\cdot}6745\, d_2)^2 &= 0, \qquad (2.) \\ \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \end{aligned}$$

and for $\delta x = x - x_0$—

$$\begin{aligned} \delta x - d_1 &= 0, \\ \delta x - d_2 &= 0, \qquad (3.) \\ \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \end{aligned}$$

with probable errors whose squares are—

$$\begin{aligned} \varepsilon_1^2 &= i_1 \xi + j_1 \eta + k_1 \zeta, \\ \varepsilon_2^2 &= i_2 \xi + j_2 \eta + k_2 \zeta, \qquad (4.) \\ \cdot \quad \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \quad \cdot \end{aligned}$$

Equations (2) and (3) must be solved by successive approximation. The value of δx is first found by equations (3). Substituting x for x_0 in (1), new values of d will be given with which to form equations (2). In the first instance the weights must be assigned arbitrarily; after that, computed in accordance with (4).

IV.

If the observed value u_0 be substituted for x_0 in (1a), we have—

$$u_1 \frac{\tau_2}{\tau_1 + \tau^2} + u_2 \frac{\tau_1}{\tau_1 + \tau_2} - u_0 = d,$$

and—

$$\varepsilon_{12}^2 = \frac{\tau_1^2 + \tau_2^2 + (\tau_1 + \tau_2)^2}{(\tau_1 + \tau_2)^2} \cdot \xi + \frac{\tau_1 \tau_2}{\tau_1 + \tau_2} \cdot \eta + \frac{\tau_1^2 \tau_2^2}{\tau_1 + \tau_2} \cdot \zeta.$$

It will also be seen that—

$$\frac{\tau_1 + \tau_2}{\tau_1 \tau_2} d = r_2 - r_1,$$

where r_1 and r_2 are the corresponding successive rates given by observation; whence we may readily obtain for the determination of ξ, η and ζ, equations of the form—

$$\frac{\tau_1^2 + \tau_2^2 + (\tau_1 + \tau_2)^2}{\tau_1^2 \tau_2^2} \cdot \xi + \frac{\tau_1 + \tau_2}{\tau_1 \tau_2} \cdot \eta + (\tau_1 + \tau_2) \cdot \zeta - [0{\cdot}6745\, (r_2 - r_1)]^2 = 0.$$

In general for clocks of the best quality ξ and ζ will be small. If, therefore, the intervals of time be equal or nearly so, we may assign to each equation, without sensible error, a weight $\frac{\tau_1 \tau_2}{\tau_1 + \tau_2}$; whence—

$$\frac{\tau_1^2 + \tau_2^2 + (\tau_1 + \tau_2)^2}{\tau_1 \tau_2 (\tau_1 + \tau_2)} \cdot \xi + \eta + \tau_1 \tau_2 \zeta - 0{\cdot}4549 \frac{\tau_1 \tau_2}{\tau_1 + \tau_2} (r_2 - r_1)^2 = 0. \qquad (5.)$$

Rates for longer intervals may be found by employing alternate observations, every third observation, &c. The sums of the individual series of equations resulting therefrom will form final equations, three of which will be sufficient to determine ξ, η and ζ.

V.

As an illustration of the process just described, I have discussed the residual rates of the standard clock of the Leiden Observatory, Hohwü No. 17, given by Professor Kaiser, in the Astronomische Nachrichten, Vol. 63, pp. 215–220.

The coefficient of ξ in (5) may be written—

$\dfrac{f\left(\frac{\tau_2}{\tau_1}\right)}{\tau_1 + \tau_2}$, where $f\left(\frac{\tau_2}{\tau_1}\right) = f\left(\frac{\tau_1}{\tau_2}\right) = 1 + \frac{\tau_2}{\tau_1} + \frac{\tau_1}{\tau_2}$. In performing the computation $f\left(\frac{\tau_2}{\tau_1}\right) = f\left(\frac{\tau_1}{\tau_2}\right)$ was taken from the following table—

$\frac{\tau_2}{\tau_1}$ or $\frac{\tau_1}{\tau_2}$.	$f\left(\frac{\tau_2}{\tau_1}\right) = f\left(\frac{\tau_1}{\tau_2}\right)$	Diff.
1·0	6·00	2
1·1	6·02	5
1·2	6·07	7
1·3	6·14	9
1·4	6·23	10
1·5	6·33	12
1·6	6·45	13
1·7	6·58	13
1·8	6·71	14
1·9	6·85	15
2·0	7·00	

Besides the rates given by Professor Kaiser, two new sets of rates were found by the formulæ—

$$r_{12} = \frac{r_1\,\tau_1 + r_2\,\tau_2}{\tau_1 + \tau_2},\ r_{34} = \frac{r_3\,\tau_3 + r_4\,\tau_4}{\tau_3 + \tau_4},\ r_{56} = \frac{r_5\,\tau_5 + r_6\,\tau_6}{\tau_5 + \tau_6},\ \text{etc.},$$

$$r_{23} = \frac{r_2\,\tau_2 + r_3\,\tau_3}{\tau_2 + \tau_3},\ r_{45} = \frac{r_4\,\tau_4 + r_5\,\tau_5}{\tau_4 + \tau_5},\ r_{67} = \frac{r_6\,\tau_6 + r_7\,\tau_7}{\tau_6 + \tau_7},\ \text{etc.};$$

and three others by the formulæ—

$$r_{13} = \frac{r_1\,\tau_1 + r_2\,\tau_2 + r_3\,\tau_3}{\tau_1 + \tau_2 + \tau_3},\ r_{46} = \frac{r_4\,\tau_4 + r_5\,\tau_5 + r_6\,\tau_6}{\tau_4 + \tau_5 + \tau_6},\ r_{79} = \frac{r_7\,\tau_7 + r_8\,\tau_8 + r_9\,\tau_9}{\tau_7 + \tau_8 + \tau_9},\ \text{etc.},$$

$$r_{24} = \frac{r_2\,\tau_2 + r_3\,\tau_3 + r_4\,\tau_4}{\tau_2 + \tau_3 + \tau_4},\ r_{57} = \frac{r_5\,\tau_5 + r_6\,\tau_6 + r_7\,\tau_7}{\tau_5 + \tau_6 + \tau_7},\ r_{810} = \frac{r_8\,\tau_8 + r_9\,\tau_9 + r_{10}\,\tau_{10}}{\tau_8 + \tau_9 + \tau_{10}},\ \text{etc.},$$

$$r_{35} = \frac{r_3\,\tau_3 + r_4\,\tau_4 + r_5\,\tau_5}{\tau_3 + \tau_4 + \tau_5},\ r_{68} = \frac{r_6\,\tau_6 + r_7\,\tau_7 + r_8\,\tau_8}{\tau_6 + \tau_7 + \tau_8},\ r_{911} = \frac{r_9\,\tau_9 + r_{10}\,\tau_{10} + r_{11}\,\tau_{11}}{\tau_9 + \tau_{10} + \tau_{11}},\ \text{etc.}$$

From each of these six sets the following quantities were derived at my request by Mr. H. V. Egbert—

No. of Equations.	$\Sigma \dfrac{f\left(\frac{\tau_2}{\tau_1}\right)}{\tau_1\,\tau_2}$	$\Sigma\,\tau_1\,\tau_2$.	$0{\cdot}4549\,\Sigma \dfrac{\tau_1\,\tau_2}{\tau_1 + \tau_2}(r_2 - r_1)^2$.
114	47·74	6176	1·2455
56	11·64	12066	0·8159
56	11·58	12104	0·5796
37	5·07	18060	0·4577
37	5·10	17896	0·7563
36	4·96	17406	0·5135

The final equations were, therefore—

$$\begin{aligned} 47{\cdot}74\,\xi + 114\,\eta + 6176\,\zeta - 1{\cdot}2455 &= 0, \\ 23{\cdot}22\,\xi + 112\,\eta + 24170\,\zeta - 1{\cdot}3955 &= 0, \\ 15{\cdot}13\,\xi + 110\,\eta + 53364\,\zeta - 1{\cdot}7275 &= 0; \end{aligned}$$

the solution of which gave—

$$\begin{aligned} \xi &= 0{\cdot}002428, \\ \eta &= 0{\cdot}009215, \\ \zeta &= 0{\cdot}000012689; \end{aligned}$$

whence—

$$\begin{aligned} \alpha &= 0^{s}{\cdot}049, \\ \beta &= 0\,{\cdot}096, \\ \gamma &= 0\,{\cdot}00617. \end{aligned}$$

As a matter of interest I have computed the interval of time required to obtain a minimum error in the predicted rate. The Square of the probable error in the rate at the time t_2 as derived from observations made at that time and the time t_1 is—

$$\epsilon_r{}^2 = \frac{2\xi}{\tau^2} + \frac{\eta}{\tau} + \zeta\tau,$$

whence, for the minimum—

$$\frac{d\frac{\epsilon^2}{\tau}}{d\tau} = -\frac{4\xi}{\tau^3} - \frac{\eta}{\tau^2} + \zeta = 0,$$

the solution of which gave $\tau = 27$ days.

Cincinnati Observatory, Mt. Lookout, Ohio.
March, 1881.

ELEMENTS OF COMET *a* 1881.

From three Dun Echt observations of May 2, 4, and 6, Mr. J. G. Lohse and the undersigned have deduced the following elements for the comet discovered by Swift on May 1 :—

$$\begin{aligned} T &= 1881 \text{ May } 20{\cdot}6651 \text{ Greenwich M. T.} \\ \left.\begin{aligned} \pi - \Omega &= 175^\circ\ 7'\ 34''{\cdot}2 \\ \Omega &= 124\ \ 53\ \ 59\ {\cdot}6 \\ i &= \ 78\ \ 47\ \ 49\ {\cdot}1 \end{aligned}\right\} & \text{ Mean Equinox 1881} \\ \log q &= 9{\cdot}767446 \\ &\text{Direct} \end{aligned}$$

These elements were issued on May 9 in Dun Echt Circular No. 17, and were transmitted by cable to Boston by a new system, devised by Messrs. S. C. Chandler, Jr., and J. Ritchie, Jr. On the following day they were circulated in the United States in a "Science Observer Circular."

Ralph Copeland.

ELEMENTE UND EPHEMERIDE DES COMETEN *a* 1881.

(*Reprinted from Dun Echt Circular No* 18, *issued to our subscribers on May* 12.)

Aus den Beobachtungen; Dun Echt 1881 Mai 2, Hamburg Mai 5 und Kiel Mai 7 leitete ich folgende Elemente und Ephemeride des neuen Cometen ab:—

$$\begin{array}{rl} T = & 1881 \text{ Mai } 20{\cdot}5521 \text{ M. Zt. Berlin.} \\ \pi - \Omega = & \left.\begin{array}{l} 174^\circ\ 8'\ 37'' \\ 126\ \ \ 7\ \ \ 7 \\ \ \ 78\ \ \ 9\ \ 40 \end{array}\right\} \text{ m. Aeq. } 1881{\cdot}0 \\ \log q = & 9{\cdot}77070 \end{array}$$

(Rows 2–4 of the bracket: $\Omega =$ 126 7 7, $i =$ 78 9 40.)

Daraus ergiebt sich folgende Ephemeride für 0^h M. Zt. Berlin.

1881	α	δ	log Δ	log r	H
Mai 10	$0^h\ 36^m\ 17^s$	$+27^\circ\ 26'{\cdot}2$	0·00562	9·80265	1·44
11	40 30	26 13·8			
12	44 51	24 59·0			
13	49 20	23 42·0			
14	53 57	22 23·1	9·98940	9·78368	1·70
15	0 58 43	21 2·4			
16	1 3 39	19 40·1			
17	8 43	18 16·2			
18	13 57	16 50·8	9·97580	9·77272	1·90
19	19 19	15 24·2			
20	24 52	13 56·6			
21	30 34	12 28·2			
22	36 24	10 59·3	9·96667	9·77136	2·00
23	42 22	9 30·2			
24	48 29	8 1·2			
25	1 54 44	6 32·5			
26	2 1 5	5 4·5	9·96365	9·77978	1·95
27	7 33	3 37·5			
28	14 7	2 11·7			
29	20 45	+0 47·5			
30	2 27 28	−0 34·6	9·96768	9·79674	1·77

Die Helle von Mai 2 ist = 1 gesetzt.

Die Darstellung der mittleren Beobachtung ist—

$$d\lambda = +4'' \qquad d\beta = -5''.$$

Die Elemente zeigen einige Aehnlichkeit mit denjenigen des Cometen No. 1 b des Galle'schen Cometen-Verzeichnisses.

DR. OPPENHEIM.

Berlin, 1881, Mai 9.

OBSERVATIONS OF COMET α 1881 (SWIFT).

Made at Dun Echt Observatory with the Filar Micrometer of the 15·06-in. refractor.

(Communicated by the Earl of Crawford and Balcarres.)

	Date. 1881.	Dun Echt Mean Time.	Comet – *		α Comet.	δ Comet.	Observer.
			Δ α.	Δ δ.			
a	May 2,	$14^h\ 2^m\ 34^s$	$-\ 3^m 48^s$	$-\ 0'\ 33''$	$0^h\ 8^m\ 35^s{\cdot}7$	$+\ 35°\ 19'\ 10''$	J. G. L.
b	„ 4,	13 22 4	– 3 49·58	– 4 12·4	0 15 31·98	+ 33 23 23·7	R. C.
c	„ „	14 0 47	– 5 42·05	– 0 56·0	0 15 37·40	+ 33 21 41·5	
d	„ 6,	13 0 41	– 1 33·93	– 9 46·6	0 22 49·55	+ 31 18 57·1	J. G. L.
	„ 7,	13 23 41	– 6 16·07	– 0 14·3	0 26 43·02	+ 30 12 21·7	R. C.
e	„ 9,	13 23 21	– 0 23·45	– 10 25·5	0 34 40·86	+ 27 55 7·0	R. C.

May 4. The observer gave double weight to the first observation.

Adopted Mean Places of Comparison Stars for 1881·0:—

	α.	Red. to date.	δ.	Red. to date.	Authority.
a	$0^h\ 12^m\ 22^s{\cdot}80$	$+\ 0^s{\cdot}91$	$+\ 35°\ 19'\ 42''{\cdot}8$	$+\ 0''{\cdot}5$	B. W. 292
b	0 19 20·59	+ 0·97	+ 33 27 35·2	+ 0·9	„ 451
c	0 21 18·49	+ 0·96	+ 33 22 36·6	+ 0·9	„ $\frac{503 + 504}{2}$
d	0 24 22·46	+ 1·02	+ 31 28 42·5	+ 1·2	„ 581
e	0 35 3·21	+ 1·10	+ 28 5 30·5	+ 2·0	„ 876

On May 7, the apparent place of the comparison star δ Andromedæ was taken from "Mittlere and scheinbare Oerter," &c.

The observers' initials, R. C. and J. G. L., indicate respectively Dr. Copeland and Mr. J. G. Lohse.

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BEITRAG ZUR KENNTNISS DER ROTATIONSELEMENTE JUPITERS.

VON DR. H. KOBOLD.

(*Vorgelegt in der Sitzung der "Magyar Tudományos Akademia," am* 16 *Mai* 1881.)

Gewiss nimmt unter den die Verhältnisse in unserem Sonnensysteme ausdrückenden constanten Zahlen die Umdrehungszeit der verschiedenen Planeten nicht den letzten Platz ein, kann sie doch möglicher Weise als ein Fingerzeig bei der Schätzung der Entstehungszeit des betreffenden Körpers dienen. Ausserdem ist nun aber die Ermittlung dieser Grösse durchaus keine so leichte Aufgabe als es auf den ersten Blick scheinen möchte. Sie kann nämlich nur an Flecken, die sich auf der Scheibe zeigen, gemacht werden, bei diesen ist nun aber eine von der Umdrehung des Planeten unabhängige eigene Bewegung nicht nur möglich, sondern sogar wahrscheinlich, da gerade bei dem uns hier beschäftigenden Planeten von Schmidt in Athen aus verschiedenen gleichzeitig sich zeigenden Flecken wesentlich verschiedene Umdrehungszeiten berechnet wurden.

Es schien mir daher in Hinblick auf diesen Umstand gerathen einen von dem gewöhnlichen Verfahren abweichenden Weg einzuschlagen, bei welchem das Hauptgewicht auf die Ermittlung absoluter jovicentrischer Positionen des Fleckes gelegt wird. Der während der letzten beiden Jahre auf dem Jupiter sich zeigende Fleck zeichnet sich durch eine ungewöhnliche Ausdehnung aus. In der Regel besteht nun die Beobachtung darin, dass man die Zeiten des Durchgangs der beiden Enden durch den mittleren Meridian Jupiters schätzt. Man befreit dann diese Zeiten vom Einflusse der Aberration und findet so unter Berücksichtigung der Phase des Planeten und der veränderlichen heliocentrischen Stellung desselben die bestimmten Momenten zugehörigen Stellungen der Mitte des Fleckes. Als mittleren Fehler der einzelnen Beobachtung nimmt Schmidt (Astr. Nach., No. 2342) im günstigen Falle $\pm 2^m$ bis $\pm 3^m$ an, giebt aber zu dass derselbe bis auf $\pm 5^m$ ja $\pm 6^m$ steigen könne. Seiner Natur nach muss dieses Verfahren durch die kurze Zeit auf die seine Anwendung beschränkt ist sehr viel zu leiden haben. Nur unter so günstigen klimatischen Verhältnissen, wie sie der Süden Europas bietet, wird es möglich sein während einer Opposition, namentlich wenn sie wie die letzte und die nächst folgenden in den Herbst oder Winter fallen, eine grosse Anzahl von Beobachtungen zu sammeln, die doch bei der Unsicherheit der einzelnen, allein Hoffnung auf ein zufriedenstellendes Resultat erwecken kann.

Weit günstiger werden aber die Aussichten, sobald man durch mikrometrische Messung den Abstand der Mitte des Fleckes von der Mitte der Scheibe ermittelt. Denn da diese Messung wenigstens innerhalb der dem Durchgang durch die Mitte der Scheibe zunächst liegenden 3 Stunden ausgeführt werden kann, so wird man sie viel leichter vor störenden Einflüssen der Atmosphäre sichern können. Die nachherige Reduktion der Beobachtungen erfordert dann freilich einen um so grösseren Aufwand von Rechnung. Die hierzu dienenden Formeln werde ich im folgenden in aller wünschenswerthen Vollständigkeit entwickeln, da dieselben, wenn auch theilweise schon häufig angewandt, meines Wissens doch noch nirgends ausführlich niedergelegt sind.

Es sei durch irgend ein Beobachtungsverfahren die Lage des fraglichen Punktes der Jupitersscheibe bestimmt in Bezug auf ein Coordinatensystem, dessen Nullpunkt mit dem Mittelpunkte der Scheibe zusammenfällt und dessen eine Axe eine Tangente an den Jupitersaequator ist und durch die stets sichtbaren Aequatorealbanden angegeben wird. Es handelt sich nun darum diese Coordinaten in absolute jovicentrische zu verwandeln durch Berüksichtigung—

1. Der Phase und der Abplattung des Planeten.
2. Der Neigung der Jupiters-Axe gegen die Ebene seiner Bahn.
3. Der veränderlichen heliocentrischen Stellung Jupiters.

Sehr schwierig würde es nun sein die drei störenden Einflüsse in aller Strenge in Rechnung zu ziehen und zwar aus dem Grunde, weil sie sämmtlich zu gleicher Zeit die Bestimmung der Position entstellen. Glücklicherweise führt aber auch hier, wie bei so vielen in der Astronomie zur Anwendung gelangenden Correktionsrechnungen ein günstiger Umstand eine bedeutende Erleichterung herbei. Auch hier können nämlich alle in den Beobachtungsdaten enthaltene Abweichungen eine gewisse kleine, ihrem Maximalwerthe nach, genau bekannte Grösse nicht überschreiten.

Die von der jovicentrischen Elongation der Erde abhängige Phase beträgt im Maximum etwa 10°. Die Neigung der Axe gegen die Bahnebene beträgt auch nur 3° und die veränderliche Stellung Jupiters kann endlich in aller Strenge berücksichtigt werden. Aus diesem Grunde ist es nun erlaubt die drei zu berechnenden Correktionen einzeln anzubringen.

Beginnen wir mit der Betrachtung der Phase. Die volle Wirkung derselben findet in einem durch das Auge des Beobachters, die Sonne und den Mittelpunkt Jupiters gelegten grössten Kreise statt. Wir werden demnach direkt diese Gesammtwirkung berechnen und dieselbe dann in zwei Componenten zerlegen, deren eine in die Bahnebene Jupiters fällt während die andere zu derselben senkrecht steht.

Da wir zunächst von der Neigung der Jupitersaxe abstrahiren, so haben wir anzunehmen, dass die Ebene seines Aequators mit seiner Bahnebene zusammenfällt. Der Radius Vector Jupiters schneidet dann die Oberfläche des Planeten in einem Punkte des Aequators, welchen wir als Nullpunkt der jovigraphischen Coordinaten betrachten wollen. Die Phase bewirkt nun, das dieser wahre Nullpunkt nicht mit dem Mittelpunkte der sichtbaren Planetenscheibe coincidirt, sondern gegendenselben sowohl in Länge als auch in Breite verschoben ist. Offenbar ist die Verschiebung in Länge für alle Punkte, welche auf einer zur Bahnebene Jupiters senkrechten demnach der Ebene seiner Meridiane parallelen Linie liegen, dieselbe, während andererseits die Verschiebung in Breite für alle Punkte gleicher jovicentrischer Breite die nämliche bleibt. Indem wir daher zunächst die jovicentrische Breite der Erde = 0 setzen, befreien wir die x Coordinate vom Einflusse der Phase, und verfahren dann analog mit der y Coordinate.

Es stelle demnach die Ebene der Zeichnung (Plate IV., fig. 1) die Bahnebene, oder was hier gleichbedeutend ist, die Ebene des Jupiter Aequators dar. In J liege der Mittelpunkte des Planeten, JS sei die Richtung nach der Sonne, JE die zum Auge des Beobachters. Von der erleuchteten Halbkugel $AFB'B$ sieht der Beobachter dann nur die Calotte AFB'; $A'B'$ erscheint als Durchmesser und die Mitte M dieser Geraden als Mittelpunkt des Planeten. Bei der Messung projicirt sich alles auf die zum Visionsradius senkrechte Gerade $A'B'$, welche mit AB und AB' den Winkel $\frac{\epsilon}{2}$ einschliesst wenn unter ϵ die Differenz der jovicentrischen Elongationen der Erde und der Sonne verstanden wird. Der wahre Mittelpunkt F des Fleckes erscheint dem Auge nach C versetzt und die Beobachtung ergiebt als Abstand des Fleckes vom Mittelpunkte der Scheibe die Länge $CD = x$. Es handelt sich nun darum aus dieser Angabe den Winkel $SJF = \lambda$ zu berechnen. Den wahren Durchmesser $AB = d$ und den Winkel ϵ dürfen wir als bekannt betrachten. Es ergiebt sich dann—

Scheinbarer Durchmesser $A'B' = d_0 = d \cos^2 \frac{\epsilon}{2}$

$$JD = \tfrac{1}{2} d \sin^2 \frac{\epsilon}{2}$$

$$(1.) \quad JC = X_1 = x - \tfrac{1}{2} d \sin^2 \frac{\epsilon}{2}$$

$$(2.) \quad \lambda_1 = \epsilon + \text{arc sin} \frac{2X}{d}$$

Die Correktion der beobachteten Breite ergiebt sich in ganz derselben Weise. Bedeutet ϵ' die Differenz der jovicentrischen Breiten von Sonne und Erde, so wird—

$$(3.) \quad JC' = Y = y - \tfrac{1}{2} d \sin^2 \frac{\epsilon'}{2}$$

$$(4.) \quad \beta = \epsilon' + \text{arc sin} \frac{2Y}{d}$$

Die so berechnete Breite ist abgesehen von der Abplattung schon fehlerfrei. An die berechnete Länge ist aber sofort noch eine Correktion anzubringen. Der beobachtete Abstand des Fleckes vom Mittelpunkte der Jupitersscheibe bezieht sich nämlich auf den Parallelkreis desselben. Um den Abstand am Aequator zu erhalten ist die Längendifferenz noch mit sec β zu multipliciren, so dass wir als Endresultat erhalten—

$$(5.) \quad X = x \sec \beta - \tfrac{1}{2} d \sin^2 \frac{\epsilon}{2}$$

$$(6.) \quad \lambda = \epsilon + \text{arc sin} \frac{2X}{d}$$

Nachträglich können wir nun auch leicht die erhaltenen Resultate vom Einflusse der Abplattung Jupiters befreien. Man bezeichne durch e die numerische Excentricität und durch $p = i\,(1 - e^2)$ den halben Parameter der elliptischen Meridiane. Nennt man dann ρ den Abstand eines Punktes der Ellipse vom Mittelpunkte derselben, bezeichnet den Winkel den diese Verbindungslinie mit der grossen Axe bildet durch β, während ε die dem betreffenden Punkte zugehörige excentrische Anomalie, r der Radiusvector ist, so lässt sich zunächst die bekannte Gleichung—

$$r = d\,(1 - e \cos \varepsilon)$$

überführen in—

$$r = d - \rho\, e \cos\beta,$$

Man hat aber auch—

$$r = \sqrt{\rho^2 + d^2 e^2 - 2\rho\, d\, e \cos\beta}$$

und findet aus beiden Werthen—

$$(7.) \qquad \rho^2 = \frac{d^2\,(1 - e^2)}{1 - e^2 \cos^2\beta}$$

Der Einfluss der Abplattung auf die Längenbestimmung besteht nun darin, dass der gemessene Winkel sich nicht wie bisher angenommen auf den Parallelkreis vom Radius $d \cos\beta$, sondern auf einen solchen vom Radius $\rho \cos\beta$ bezieht. In beiden entspricht derselben Grösse X ein verschiedener Winkel und zwar drückt sich die Beziehung zwischen beiden durch die Formel aus—

$$\sin(w + \Delta w) : \sin w = d \cos\beta : \rho \cos\beta$$

so dass—

$$\sin(w + \Delta w) = \sqrt{\frac{1 - e^2 \cos^2\beta}{1 - e^2}}\, \sin w$$

wird.

Man erhält so als definitiven Ausdruck für die gesuchte Länge—

$$(8.) \qquad \lambda_0 = \varepsilon + \operatorname{arc\,sin} \sqrt{\frac{1 - e^2 \cos^2\beta}{1 - e^2}}\; \frac{2\,X}{d}$$

wobei X nach Formel (5) zu berechnen ist.

Weit weniger einfach ist die Berücksichtigung der Abplattung bei der zweiten Coordinate. Das Auge des Beobachters blicke in der gegen die Ebene des Aequators unter dem Winkel ε' geneigten Geraden JE (Plate IV., fig. 2). Es wird dann den in F befindlichen Fleck nach F' versetzen. Unter dieser Annahme berechneten wir die scheinbare Breite β des Fleckes. In dem Dreiecke JFF' hat man aber—

$$\sin(\beta - \varepsilon') : \sin\,[180^\circ - (\beta - \varepsilon') - \Delta\beta] = \rho + \Delta\rho : d$$

$$\sin(\beta - \varepsilon' - \Delta\beta) = \frac{d \sin(\beta - \varepsilon')}{\rho + \Delta\rho}$$

Entwickelt man nun die linke Seite nach $\Delta\beta$ bis auf Grössen zweiter Ordnung, so wird—

$$\sin(\beta - \varepsilon') - \cos(\beta - \varepsilon')\, \Delta\beta = \frac{d \sin(\beta - \varepsilon')}{\rho + \Delta\rho}$$

woraus sich unter Benutzung der Gleichung—

$$\frac{d\rho}{d\beta} = -\frac{\rho}{2}\, \frac{e^2 \sin 2\beta}{1 - e^2 \cos^2\beta}$$

ergiebt—

$$(9.)\qquad \Delta\beta = \frac{2\,\frac{d-\rho}{\rho}\sin(\beta-\varepsilon')}{\frac{e^2\sin 2\beta}{1-e^2\cos^2\beta}\sin(\beta-\varepsilon') + 2\cos(\beta-\varepsilon')}$$

Sollte die so gefundene Correktion noch nicht genügend erscheinen, so berechne man mit ihr den Werth von $\Delta\rho$ aus der gegebenen Differentialgleichung und löse dann die Gleichung—

$$\sin(\beta-\varepsilon'-\Delta\beta) = \frac{d\sin(\beta-\varepsilon')}{\rho+\Delta\rho}$$

direkt für $\Delta\beta$ auf. Dies Verfahren wiederhole man so lange bis die Werthe von $\Delta\beta$ constant werden.

Bei der Anwendung hat sich nun gezeigt dass man dies strenge Verfahren wenigstens innerhalb mässiger Breiten durch eine Näherungsformel ersetzen kann, welche durch die Annahme $\Delta\rho = 0$ entsteht.

Es wird dann einfach—

$$\begin{aligned}\sin(\beta-\varepsilon'-\Delta\beta) &= \frac{d}{\rho}\sin(\beta-\varepsilon')\\ &= \sqrt{\frac{1-e^2\cos^2\beta}{1-e^2}}\sin(\beta-\varepsilon')\end{aligned}$$

also analog Gleichung (8)—

$$(10.)\qquad \beta_0 = \varepsilon' + \text{arc}\sin\sqrt{\frac{1-e\cos^2\beta}{1-e^2}}\,\frac{2Y}{d}$$

wobei Y wieder durch Formel (3) zu berechnen ist.

Hiernach ist nun die Berechnung der Hülfswinkel ε und ε' zu zeigen. Dieselbe erfordert zunächst die Kenntniss des Winkels J den der Radius Vector der Erde in einem bestimmten Momente mit der Ebene der Jupitersbahn bildet. Bezeichnet man mit i den Neigungswinkel der Jupitersbahn gegen die Ecliptic, mit ☊ die Länge ihres aufsteigenden Knotens und mit ⊙ die dem Augenblicke entsprechende Länge der Sonne, so erhält man leicht—

$$\sin J = \sin i \sin(☊ - ⊙).$$

Aus einem Jahrbuche (am bequemsten ist die Connaissance des Temps) entnehme man die Differenzen l und b der heliocentrischen und geocentrischen Länge und Breite Jupiters und berechne mit ihrer Hülfe den jovicentrischen Abstand der Erde von der Sonne mittelst der Formel—

$$\cos w = \cos l \cos b.$$

Mit Hülfe dieser Grössen ergiebt sich dann leicht—

$$(11.)\qquad \tan\varepsilon = \tan w \cos J$$

$$(12.)\qquad \sin\varepsilon' = \sin w \sin J$$

Um nun schliesslich ein Urtheil über die Genauigkeit der erhaltenen Positionen fällen zu können differentiire man die Gleichungen (3) und (5). Man erhält dann—

$$\frac{d\lambda}{dx} = 2\frac{dX}{dx}\frac{1}{\sqrt{1-\frac{4X^2}{d^2}}}\qquad\qquad \frac{d\beta}{dy} = 2\frac{dY}{dy}\frac{1}{\sqrt{1-\frac{4Y^2}{d^2}}}$$

$$(13.)\qquad \Delta\lambda = \frac{2}{d\sqrt{1-\frac{4X^2}{d^2}}}\,\Delta x$$

$$(14.)\qquad \Delta\beta = \frac{2}{d\sqrt{1-\frac{4Y^2}{d^2}}}\,\Delta y$$

Hiermit sind die Beobachtungen nun von jedem durch die Stellung der Erde herbeigeführten Einflusse befreit, so dass wir uns bei dem nun folgenden zweiten Theile der Aufgabe, der Reduction der Beobachtungen auf ein absolutes System in den Mittelpunkt der Sonne versetzen können. Der Coordinatenanfang des bisher zu Grunde gelegten Systems lag im Mittelpunkte Jupiters, die Fundamentalebene fiel mit der Bahnebene, und in ihr die X Axe mit dem jeweiligen Radius Vector des Planeten zusammen. Als xy Ebene des neuen Systems wählen wir naturgemäss die Aequatorebene Jupiters, als Z Axe demnach die Polaraxe des Planeten. Die gegenseitige Beziehung beider Systeme wird dadurch festgestellt, dass wir gemäss der üblichen und, bis widersprechende Erfahrungen vorliegen, auch beizubehaltenden Annahme die Aequatorebene mit der bekannten Bahnebene des dritten Trabanten zusammenfallen lassen. Den Anfangspunkt der Längenzählung verlegen wir nach dem aufsteigenden Knoten des Jupiter-Aequators auf der Bahnebene jenes Planeten. Da demnach das neue System dem irdischen System der Rectascensionen und Declinationen völlig entspricht, so werden wir demzufolge die neuen Coordinaten auch durch α und δ bezeichnen.

Um nun das alte System in das neue zu überführen nehmen wir eine doppelte Drehung vor. Zuerst nämlich drehen wir um die Z-Axe des alten Systems und zwar um den zwischen dem Radius Vector und der Knotenlinie enthaltenen Winkel—

$$180^\circ + \text{♃} - \text{☊}_*$$

in welchem Ausdrucke $\text{♃} - \text{☊}$ den in der Jupitersbahn zwischen dem Ort des Planeten und dem aufsteigenden Knoten des Aequators gelegenen Bogen bezeichnet. Hierauf vollführen wir die zweite Drehung um die jetzt gemeinsame X Axe, die Knotenlinie, und zwar um den Neigungswinkel i_* beider Ebenen.

Durch die erste Drehung gehen nach den Transformationsformeln der analytischen Geometrie die alten Coordinaten x, y, z über in—

$$\begin{aligned} x_1 &= -x\cos(\text{♃} - \text{☊}_*) + y\sin(\text{♃} - \text{☊}_*),\\ y_1 &= -x\sin(\text{♃} - \text{☊}_*) - y\cos(\text{♃} - \text{☊}_*),\\ z_1 &= z. \end{aligned}$$

Die zweite Drehung verwandelt diese Coordinaten in—

$$\begin{aligned} x^1 &= x_1 &&= -x\cos(\text{♃} - \text{☊}_*) + y\sin(\text{♃} - \text{☊}_*)\\ y^1 &= \cos i_*\, y_1 - \sin i_*\, z_1 &&= -x\sin(\text{♃} - \text{☊}_*)\cos i_* - y\cos(\text{♃} - \text{☊}_*)\cos i_* - z\cos i_*\\ z^1 &= \sin i_*\, y_1 + \cos i_*\, z_1 &&= -x\sin(\text{♃} - \text{☊}_*)\sin i_* - y\cos(\text{♃} - \text{☊}_*)\sin i_* + z\cos i_*. \end{aligned}$$

Ersetzt man nun die rechtwinkligen Coordinaten durch Polarcoordinaten und wendet die Summationsformeln der Trigonometrie an, so erhält man als Transformationsgleichungen folgendes System—

$$(15.)\quad \left\{\begin{array}{l} a \sin A = \cos\beta \sin(\text{♃} - \text{☊}_{*} + \lambda) \\ a \cos A = \sin\beta \\ \operatorname{tang} A = \operatorname{cotang}\beta \sin(\text{♃} - \text{☊}_{*} + \lambda) \\ \cos\alpha \cos\delta = -\cos\beta \cos(\text{♃} - \text{☊}_{*} + \lambda) \\ \sin\alpha \cos\delta = -a \sin(A + i_{*}) \\ \sin\delta = a \cos(A + i_{*}) \end{array}\right.$$

Die Grössen α und δ bilden das gesuchte Resultat, so dass also hiermit die Umrechnung als vollendet zu betrachten ist.

Im Anschluss an diese Entwicklungen werde ich nun im folgenden eine Reihe von Beobachtungen besprechen, die während der letzten Opposition Jupiters und zwar innerhalb der Zeit von August 27, 1880 bis Januar 14, 1881 von mir auf der O'-Gyalla Sternwarte angestellt sind. Zur Kenntniss der Grössen x und y der Formeln (3) und (5) führte die Registriermethode. Es wurden nämlich an einem nach der Richtung der gewählten Coordinatenaxen eingestellten rechtwinkligen Fadensysteme die Antritte des Ost- und West-, Nord- und Südrandes der Jupitersscheibe und des auf ihr befindlichen Fleckens registrirt. Die zur Längenbestimmung dienende Messung wurde immer 25 bis 30 Mal, die andere dagegen nur 15 bis 20 Mal ausgeführt, weil hier der einzelnen Beobachtung ein grösseres Gewicht zukam. Um möglichst grosse Sicherheit zu erzielen wurde stets bei beträchtlicher Vergrösserung beobachtet. Die Reduktion ergab nun freilich, dass durch diese Methode die wünschenswerthe Genauigkeit nicht völlig zu erreichen ist, so dass die Ergebnisse nur mit Rückhalt dürfen aufgenommen werden. Bei der nächstfolgenden Opposition beabsichtige ich, wenn nur überhaupt Gelegenheit zu ähnlichen Beobachtungen geboten wird, auch diesen Mangel dadurch zu beseitigen, dass ich die Durchgangszeit der Scheibe vor den Fäden dadurch wesentlich vergrössere, dass ich das Fernrohr durch ein gegen die Bewegung der Gestirne bedeutend voreilendes oder hinter derselben zurückbleibendes Uhrwerk antreiben lasse. Dieses von de Gasparis zuerst angewandte Verfahren scheint mir gerade für den vorliegenden Zweck in hohem Grade geeignet zu sein.

Die Discussion von 190 einzeln berechneten Beobachtungen ergab als mittleren Fehler der einzelnen Messung von x, dass heisst des Längenabstandes der Mitte des Fleckes von der Mitte der Scheibe—

$$0^{s}{\cdot}1827$$

die auftretenden Extreme waren $0^{s}{\cdot}246$ und $0^{s}{\cdot}139$. Bedenkt man, dass sich dieser Fehler aus den bei der Auffassung der vier verschiedenen Momente begangenen zusammensetzt, so wird seine Grösse kaum überraschen. Nimmt man an, dass die einzelne Position im Durchschnitt aus 25 Beobachtungen abgeleitet ist, wobei man gewiss hinter dem Mittel der verschiedenen Beobachtungstage beträchtlich zurückbleibt, so erhält man als mittleren Fehler des arithmetischen Mittels—

$$\varepsilon(x) = \pm\, 0^{s}{\cdot}0366$$

und als wahrscheinlichen Fehler—

$$r(x) = \pm\, 0^{s}{\cdot}0247$$

Bei den Declinations Messungen ergab sich in ähnlicher Weise—

Mittlerer Fehler der einzelnen Beobachtung von $y = 0^{s}{\cdot}1635$

„ „ des arithmetischen Mittels aus 15 Beobachtungen $\varepsilon(y) = \pm\, 0^{s}{\cdot}0422$

Wahrscheinlicher „ „ „ „ $r(y) = \pm\, 0{\cdot}0285$

Mit Hülfe dieser Werthe wurden die wahrscheinlichen Fehler der einzelnen Beobachtungen abgeleitet und zwar der der Länge für jede einzelne Beobachtung, der der Breite aber nur für das arithmetische Mittel.

Zur Herleitung der Grössen λ und β wurden der Connaissance des Temps die Werthe der Halbmesser Jupiters in der Entfernung 1 wie folgt entnommen—

$$\tfrac{1}{2}d_1 = 99''{\cdot}703$$

$$\tfrac{1}{2}d'_1 = 92''{\cdot}425$$

Nach dem Berliner Jahrbuche wurde in Bezug auf die Mittlere Ecliptic und Aequinoctium 1880·0 gesetzt—

$$i = 1^\circ\ 18'\ 40''{\cdot}1$$

$$\Omega = 99^\circ\ 12'\ 30''{\cdot}0$$

Bezüglich der Transformationsconstanten wurde nach Damoiseau für 1750·0 angenommen—

$$i_* = 3^\circ\ 4'\ 5'' \qquad \Omega_* = 313^\circ\ 21'\ 55''$$

Für die Jährliche Veränderung dieser Grössen giebt Laplace im 4ten Bande der Mécanique céleste—

$$\Delta i_* = +\ 0''{\cdot}02279\, t$$

$$\Delta\,\Omega_* = +\ 49''{\cdot}83\, t$$

Hiernach wurde für 1880·0 gefunden—

$$i_* = 3^\circ\ 4'\ 35'' \qquad \Omega_* = 315^\circ\ 9'\ 53''.$$

Die hiermit ausgeführten Rechnungen führten zu folgendem Resultate—

Beobachtungszeit in Sternzeit.	x.	y.	λ.	$r(\lambda)$.	β.	α.	δ.
1880.							
August 27, 21h 26m 48s	$-0^{s}{\cdot}174$	$-0^{s}{\cdot}545$	$+\ 1^\circ\ 11'$	$\pm 53'$	$-\ 20^\circ\ 20'$	$236^\circ\ 8'$	$-\ 22^\circ\ 53'$
September 1, 21 51 31	$+\ 0{\cdot}612$	$-\ 0{\cdot}534$	$+\ 30\ 56$	59	19 20	266 57	22 24
„ 25, 23 7 3	$+\ 0{\cdot}586$	$-\ 0{\cdot}662$	$+\ 25\ 13$	60	23 29	263 20	26 33
October 2, 23 23 27	$-\ 0{\cdot}121$	$-\ 0{\cdot}602$	$-\ 1\ 10$	50	21 9	237 19	22 54
„ 7, 22 21 11	$-\ 0{\cdot}500$	$-\ 0{\cdot}627$	$-\ 19\ 8$	53	22 9	219 14	24 7
„ 14, 0 36 40	$+\ 0{\cdot}405$	$-\ 0{\cdot}646$	$+\ 13\ 14$	52	22 51	252 52	25 48
„ 16, 1 29 3	$-\ 0{\cdot}370$	$-\ 0{\cdot}663$	$-\ 16\ 12$	52	23 32	223 0	25 39
„ 25, 19 48 12	$+\ 0{\cdot}711$	$-\ 0{\cdot}689$	$+\ 24\ 29$	58	24 46	265 23	27 50
November 2, 2 9 29	$+\ 0{\cdot}222$	$-\ 0{\cdot}655$	$+\ 3\ 1$	52	23 47	244 12	26 33
„ 28, 5 2 17	$+\ 0{\cdot}032$	$-\ 0{\cdot}673$	$-\ 7\ 57$	55	26 8	235 19	28 41
December 12, 21 54 3	$+\ 0{\cdot}248$	$-\ 0{\cdot}592$	$+\ 0\ 28$	58	24 7	245 17	26 55
„ 20, 4 13 6	$-\ 0{\cdot}293$	$-\ 0{\cdot}597$	$-\ 23\ 58$	61	25 7	221 5	27 10
„ 26, 0 53 27	$+\ 0{\cdot}627$	$-\ 0{\cdot}538$	$+\ 18\ 41$	69	22 56	265 17	26 0
„ 28, 1 26 18	$-\ 0{\cdot}199$	$-\ 0{\cdot}546$	$-\ 19\ 58$	62	23 30	225 58	25 45
1881.							
Januar 1, 5 1 17	$-\ 0{\cdot}177$	$-\ 0{\cdot}539$	$-\ 19\ 30$	63	23 31	226 39	25 46
„ 2, 1 23 26	$+\ 0{\cdot}092$	$-\ 0{\cdot}518$	$-\ 6\ 34$	62	22 35	239 56	25 15
„ 14, 2 11 44	$+\ 0{\cdot}184$	$-\ 0{\cdot}545$	$-\ 1\ 14$	65	24 56	246 9	27 45

Für das Mittel der Breiten ergab sich als wahrscheinlicher Fehler—

$$r(\beta) = \pm 1^\circ\, 11'$$

Es handelte sich jetzt darum dasjenige System der Rotationselemente Jupiters zu bestimmen, welches diesen Beobachtungen am besten genügt. Als Epoche ϵ wählen wir dabei den Beginn der auf das Perihel Jupiters, 1880 September 25 13^{h} M. Z. Berlin, zunächst folgenden Umdrehung. Als zweite Unbekannte tritt die siderische Umdrehungszeit Jupiters, das heisst die zwischen zwei auf einander folgenden Durchgängen der Mitte des Fleckens durch denselben Meridian liegende Zeit, ausgedrückt in irdischer Sternzeit. Eine vorläufige abgekürzte Reduction unter Annahme der Umdrehungszeit—

$$u = 9^{h}\, 57^{m}\, 13^{s}{\cdot}2$$

ergab als arithmetisches Mittel—

$$\epsilon = 1880 \text{ September } 25,\ 1^{h}\, 41^{m}\, 26^{s}$$

Mit diesen Grössen ergaben sich nun aus den Beobachtungen die folgenden Bedingungsgleichungen—

1880.										
August	27,	21^{h}	26^{m}	48^{s} St. Z.	$+ 70{\cdot}3441$	$\{9^{h}\, 57^{m}\, 13^{s}{\cdot}2 + x\}$	— September 25	$1^{h}\, 41^{m}\, 26^{s}$	$- y$	$= 0$
September	1,	21	51	31	$+ 58{\cdot}2585$	„	„	„	„	$= 0$
„	25,	23	7	3	$+ 0{\cdot}2685$	„	„	„	„	$= 0$
October	2,	23	23	27	$- 16{\cdot}6592$	„	„	„	„	$= 0$
„	7,	22	21	11	$- 28{\cdot}6090$	„	„	„	„	$= 0$
„	14,	0	36	40	$- 45{\cdot}7024$	„	„	„	„	$= 0$
„	16,	1	29	3	$- 50{\cdot}6167$	„	„	„	„	$= 0$
„	25,	19	48	12	$- 71{\cdot}7372$	„	„	„	„	$= 0$
November	2,	2	9	29	$- 91{\cdot}6783$	„	„	„	„	$= 0$
„	28,	5	2	17	$- 154{\cdot}6537$	„	„	„	„	$= 0$
December	12,	21	54	3	$- 187{\cdot}6814$	„	„	„	„	$= 0$
„	20,	4	13	6	$- 207{\cdot}6141$	„	„	„	„	$= 0$
„	26,	0	53	27	$- 221{\cdot}7369$	„	„	„	„	$= 0$
„	28,	1	26	18	$- 226{\cdot}6277$	„	„	„	„	$= 0$
1881.										
Januar	1,	5	1	17	$- 236{\cdot}6296$	„	„	„	„	$= 0$
„	2,	1	23	26	$- 238{\cdot}6665$	„	„	„	„	$= 0$
„	14,	2	11	44	$- 267{\cdot}6838$	„	„	„	„	$= 0$

Die Auflösung dieser Gleichungen nach der Methode der kleinsten Quadrate ergab—

$$x = + 0^{s}{\cdot}971 \qquad y = - 111^{s}{\cdot}6$$

und damit—

$$u = 9^{h}\, 57^{m}\, 14^{s}{\cdot}171$$

$$\epsilon = \text{September } 25\ \ 1^{h}\, 39^{m}\, 34^{s} \text{ St. Z.}$$

Mit diesen Werthen wurden nun rückwärts die zu den verschiedenen Beobachtungszeiten gehörenden Rectascensionen des Fleckes gerechnet um mit der Beobachtung verglichen zu werden. Das Ergebniss war folgendes—

1880.	August	27,	21^{h}	26^{m}	48^{s}	$\alpha = 235^\circ$	$41'$	$B - R = + 0^\circ$	$27'$
	September	1,	21	51	31	262	35	+ 4	22
	„	25,	23	7	3	258	6	+ 5	14
	October	2,	23	23	27	233	55	+ 3	24
	„	7,	22	21	11	216	23	+ 2	51
	„	14,	0	36	40	254	3	− 1	11
		16,	1	29	3	221	37	+ 1	23
	„	25,	19	48	12	268	10	− 2	47

1880.	November	2,	2^h	9^m	29^s	$\alpha = 241°$	57′	$B - R = +2°$	15′
	„	28,	5	2	17	234	4	+1	15
	December	12,	21	54	3	247	56	−2	39
	„	20,	4	13	6	220	23	+0	43
	„	26,	0	53	27	268	3	−2	46
	„	28,	1	26	18	223	50	+2	8
1881.	Januar	1,	5	1	17	225	56	+1	13
	„	2,	1	23	26	242	6	−2	10
	„	14,	2	11	44	247	10	−1	1

Wie man erkennt zeigen namentlich die ersten 5 Beobachtungen Abweichungen gegen die Ephemeride, die kaum als Beobachtungsfehler erklärt werden können. Weit besser schliesst sich die Ephemeride später an die Beobachtungen an, wenn auch die Darstellung durchaus keine gute zu nennen ist.

Es schien mir daher geboten unter Ausschluss der ersten 5 Gleichungen das System noch einmal aufzulösen um einen besseren Anschluss zu erhalten. So gelangte ich zu folgenden definitiven Rotationselementen—

$$\epsilon = 1880 \text{ September } 25 \; 1^h \; 37^m \; 6^s_{\cdot} \pm 89^s{\cdot}3$$
$$u = 9^h \; 57^m \; 14^s{\cdot}990 \pm 0^s{\cdot}52$$

Der mittlere Fehler der einzelnen Beobachtung ergab sich zu—

$$\epsilon = \pm 2° \; 4'$$

Da er an Grösse das Mittel der wahrscheinlichen Fehler um mehr als das doppelte übertrifft, so muss daraus, wenn man anders den Beobachtungen nicht durchschnittlich weit grössere Fehler zuschreiben will, geschlossen werden dass der Fleck noch eine von der durch die Umdrehung Jupiters erzeugten unabhängige eigene Bewegung besitze. Wollte man aber die Abweichung ganz durch die Unzuverlässlichkeit der Beobachtung erklären, so müsste der mittlere Fehler der einzelnen Beobachtung das auftretende Maximum von $0^s{\cdot}264$ weit überschreiten. Es bleibt also nur übrig eine veränderliche eigene Bewegung des Fleckens anzunehmen.

In den Beobachtungen namentlich in den Declinationsmessungen giebt sich eine solche auch mit hinreichender Uebereinstimmung zu erkennen. Die Vergleichung der aus den Constanten folgenden Rectascensionen mit den beobachteten und des Mittels—

$$M = -25° \; 45'$$

aller Declinationen mit den einzelnen führte nämlich zu folgendem Resultate—

1880.	August	27,	21^h	26^m	48^s	$\alpha = 237°$	45′	$B_a - R_a = -1°$	37′	$\delta - M\delta = +2°$	52′
	September	1,	21	51	31	272	36	−5	39	+3	21
	„	25,	23	7	3	269	56	−6	36	−0	48
	October	2,	23	23	27	235	18	+2	1	+2	51
	„	7,	22	21	11	217	39	+1	25	+1	38
	„	14,	0	36	40	252	10	+0	42	−0	3
	„	16,	1	29	3	222	41	+0	19	+0	6
	„	25,	19	48	12	269	4	−3	41	−2	5
	November	2,	2	9	29	242	43	+1	29	−0	48
	„	28,	5	2	17	234	17	+1	2	−2	56
	December	12,	21	54	3	247	52	−2	35	−1	10
	„	20,	4	13	6	220	10	+0	55	−1	25
	„	26,	0	53	27	267	41	−2	24	−0	15
	„	28,	1	26	18	223	27	+2	31	±0	0
1881.	Januar	1,	5	1	17	224	58	+1	41	−0	1
	„	2,	1	23	26	241	38	−1	42	+0	30
	„	14,	2	11	44	246	27	−0	18	−2	0

Wie man noch deutlicher aus der kleinen Karte (Plate IV., Fig. 3), sieht, schliessen sich die Declinationsdifferenzen recht gut an eine ziemlich ruhig verlaufende Curve an, während die Rectascensionen starke und scheinbar ganz unregelmässige Schwankungen um eine mittlere Lage zeigen. Besonders stark tritt die Abweichung im September hervor, wo der Fleck um mehr denn 5° hinter seiner mittleren Lage zurückblieb, so dass sein Durchgang durch den mittleren Meridian der Jupitersscheibe um 4^m zu spät erfolgen musste.

Bildet man nun schliesslich durch Zusammenfassung nahe liegender Beobachtungen eine Anzahl von Normalörtern, so wird man in diesen auch bezüglich der Rectascensionen leicht einen regelmässigen Gang erkennen. Wir werden darauf aber später noch zurückkommen.

Zunächst müssen hier die über die Ausdehnung des Fleckens angestellten Messungen Platz finden, die doch ein wesentliches Moment für die Feststellung von Veränderungen bilden. Die nöthigen Daten ergaben sich von selbst bei der in der angegebenen Weise angestellten Beobachtung in den zwischen den Antritten beider Ränder des Fleckens liegenden Zwischenzeit f_0 beziehungsweise f'_0. Unter Zugrundelegung des Jupiterhalbmessers als Längeneinheit und unter Annahme einer elliptischen Gestalt des Fleckes wurde die Ausdehnung nach den Formeln berechnet—

Länge, $$L = 2\,\frac{f_0}{d_0}\sec\lambda_0$$

Breite, $$B = 2\,\frac{f'_0}{d'_0}\sec\beta_0$$

Flächeninhalt, $$F = \tfrac{1}{4}\,L.\,B.\,\pi.$$

Dabei bezeichnet λ_0 und β_0 die Längen- und Breitendifferenz der Mitte des Fleckes gegen die Mitte der Scheibe. Für die verschiedenen Beobachtungstage ergab sich so—

1880.	August	27,	$L = 0{\cdot}573\ r$	$B = 0{\cdot}258\ r$	$F = 0{\cdot}116\ r^2$
	September	1,	0·532	0·246	0·103
	„	25,	0·537	0·242	0·102
	October	2,	0·602	0·248	0·117
	„	7,	0·491	0·268	0·103
	„	14,	0·517	0·245	0·099
	„	16,	0·546	0·293	0·126
	„	25,	0·483	0·332	0·126
	November	2,	0·542	0·320	0·136
	„	28,	0·581	0·309	0·141
	December	12,	0·524	0·288	0·118
	„	20,	0·505	0·309	0·123
	„	26,	0·500	0·296	0·116
	„	28,	0·590	0·265	0·123
1881.	Januar	1,	0·553	0·311	0·135
	„	2,	0·602	0·255	0·120
	„	14,	0·554	0·281	0·122
Mittelwerthe			$0{\cdot}543\ r = 31^\circ{\cdot}1$	$0{\cdot}280\ r = 16^\circ{\cdot}0$	$0{\cdot}119\ r^2 =$ 391 Quadrat Grade.

Man erkennt leicht, dass grössere Schwankungen sich nur in Gestalt des Fleckens bemerkbar machen, während sein Flächeninhalt sich im allgemeinen viel constanter

erwies. Derselbe beträgt übrigens nach den gefundenen Zahlen 10169000 Quadrat Meilen oder das 1·38 fache der Erdoberfläche.

Um nun zu einer bequemen Uebersicht des Gesammtergebnisses zu gelangen, wird es zweckmässig sein durch Zusammenfassung nahe liegender Beobachtungen eine Anzahl von Normalörtern zu bilden, die dann möglichst wenig von den Fehlern der einzelnen Beobachtungen beeinflusst sein werden und so am sichersten über Aenderungen entscheiden werden.

Auf diesem Wege ergab sich folgende Uebersicht.

1880.						
August 30,	0^h M. Z.	$\alpha_B - \alpha_R =$ − 3° 38′	$\delta - M_\delta =$ + 3° 6′	$L =$ 0·552	$B =$ 0·252	$F =$ 0·110
October 1,	19	− 1 3	+ 1 14	0·543	0·259	0·107
„ 22,	10	− 0 18	− 0 42	0·522	0·297	0·122
December 10,	10	− 0 13	− 1 50	0·537	0·302	0·124
1881.						
Januar 2,	4	− 0 2	− 0 21	0·560	0·282	0·125

Epoche = 1880, September 25, 1^h 37^m 6^s

Dauer des siderischen Jupitertages, 9^h 57^m $14^s{\cdot}99$ St. Z. = 9^h 55^m $37^s{\cdot}15$ M. Z.

„ „ mittleren „ 9 57 5·05 „ 9 55 27·21 „

O'Gyalla, Sternwarte, 1881, Mai 20.

THE INSTRUMENTS IN THE OLD OBSERVATORY AT PEKING.

By J. L. E. DREYER.

When the Missionaries of the Society of Jesus in the seventeenth century made their way to Peking, and startled the scientists of the Celestial Empire by their superior knowledge, they found in the eastern part of the city, on the rampart or wall surrounding it, an astronomical observatory furnished with several old instruments. Father Verbiest gained the confidence of the Emperor by repeatedly calculating beforehand the exact length of the shadow which a gnomon would throw at noon, and was authorized to have six new large instruments constructed. He has himself described these in a work with the following title—"Astronomia Europæa sub imperatore Tartaro Sinico Cam Hy appellato, ex umbra in lucem revocata a R. P. Ferdinando Verbiest, Flandro Belga, e Societate Jesu, Academiæ astronomicæ in regia Pe Kinensi Præfecto" (Dillingæ, 1687, 4to).* He seems to have paid no attention whatever to the old instruments which had to be removed to make room for his own, at least he says nothing about them in his book, except (p. 47) that the Emperor gave him leave to construct new instruments, "prioribus instrumentis Sinicis rudioris Minervæ, quæ jam a trecentis proxime annis speculam occupabant, inde amotis."

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* This book seems to be rather scarce. Through the kindness of the Rev. S. J. Perry, F.R.S., I have been able to examine a copy of it. Delambre gives an account of it in his Histoire de l'Astronomie du Moyen Age, pp. 213 & seq.

These despised instruments, as well as those erected by Father Verbiest, are still in existence. Some time ago I received from a friend residing in China, Mr. S. M. Russell, a series of photographs of these interesting scientific relics, and having had my attention drawn to them in this way, I have thought that a short account of them might be read with some interest, the more so as there has not been much published about them hitherto.

The only plate in Verbiest's book represents the platform on which the six new instruments were mounted. It forms a square with two small additions to the north-east corner, one of which is the head of the staircase leading up to the platform, while the other was occupied by a small house to which the observers could retire in bad weather. Next the staircase, on the north side of the platform, was a high mast, with a weathercock. Next to this was a sextant of six feet radius (pedes geometrici), evidently an imitation of Tycho Brahe's Sextans bipartitus minoribus siderum distantiis inserviens,* which it exactly resembles with the exception that the arc is single. The arc was divided to 15″†, and the observations were taken "per pinnacidia rimosa more Tychonico."‡ In the north-west corner was a quadrant (with the arc downwards), turning in azimuth round an axis which passed through the middle of the horizontal radius. In the middle of the west side of the platform was an azimuth circle supported on four legs, and having in the middle a vertical axis, the upper end of which is joined by wires to the two ends of an alhidade, which can be turned round the axis to any azimuth. In the south-west corner stood a Zodiacal armillary sphere, while a corresponding equatoreal one occupied the south-east corner, a revolving sidereal globe, six feet in diameter, being placed between them. Lastly, the middle of the east side of the platform was taken up by a low square tower, in the four corners of which four Mandarins were posted day and night to observe the weather, meteors, &c., concerning which they prepared a daily report.

It would be needless to describe these instruments in detail; they are true copies of the astronomical instruments devised and constructed by Tycho Brahe, and generally used long after his time. They were not furnished with telescopes. The photographs show with certainty that they have been moved about since they were mounted in 1673, for they no longer occupy the places they did then, as described above. Moreover, a new instrument has been added to the collection (but *when,* I have not been able to find out), viz., another azimuthal quadrant. This instrument differs from all the others in not being profusely ornamented with dragons and serpents; on the contrary, the mounting is in very pure European style. Possibly it was constructed some time during the eighteenth century, when the missionaries felt more at home and less afraid of dispensing with what they regarded as heathen symbols.

* Astronomiæ instauratæ Mechanica, fol. D. 3.

† Probably by means of transversals.

‡ Astronomia Europæa, p. 52.

Besides these instruments on the roof of the old observatory, there are still in existence two others looking equally large and imposing, which are placed inside low brick enclosures in a kind of yard adjoining the observatory. These two I, in common with many others, had hitherto attributed to Verbiest, on account of their not differing materially from his instruments. However, when I came across a paper by Mr. A. Wylie, entitled "The Mongol Astronomical Instruments in Peking,"[*] I found that they were in fact two of the old instruments which Verbiest had removed from the observatory. At what time they were placed in their present positions appears to be unknown; Gaubil states that he was not permitted to obtain sight of them, and that they were kept in a closed room.[†] This agrees with what Father Le Compte says, who was in Peking about the year 1688, and who saw them through a window "close set with iron bars."[‡] They are now easily accessible.

According to Mr. Wylie, well-informed natives state that these instruments were made during the Yuen dynasty, and he quotes a Chinese description of Peking, in which the observatory and four large instruments (two of which from the description, can be identified as the two still extant) are said to have been constructed in the year A.D. 1279. This date brings us back to one of the most interesting periods of Chinese history, as it was in 1279 that Koblai Khan, the great Mongol monarch and grandson of Djenghis Khan, completed the conquest of China, and took up his residence in the new city, Taydo, now called Pe-king. Very different from his ancestors, Koblai was a monarch who favoured science and arts; he supported and protected the astronomer Ko Show-King, who, from having had the control of the waterways of the empire, was appointed in 1276 to examine the system of chronology then in use. Ko Show-King got the observatory built, and constructed a number of instruments, all of which are counted up in the *Yuen she*, or History of the Yuen (i.e., Mongol) dynasty. The descriptions, as translated by Mr. Wylie, are very difficult to understand, except in the case of the instruments *Keen e*, or Equatoreal, and *Ling-lung e*, or Armillæ, these being the two standing at the present moment in the courtyard of the old observatory. About this identity there can be no doubt, as the above-mentioned description of Peking expressly states, that the *Keen e* and the *Ling-lung e* were removed in 1673 from the platform, and stored away at the foot of the building. Gaubil (l.c.) also says that the instruments which in his time were kept "dans une salle fermée," were made by Ko Show-King.

It would only tire the reader if I were to reproduce the whole of the elaborate description of the Chinese writer, the more so as this would only be intelligible when compared with a picture of the instruments. What I wish to call attention to in these pages is, that we have here two remarkable instances of how the Chinese people often came into possession of great inventions many centuries before the western nations enjoyed them. We find here in the thirteenth century the equatoreal armillæ of Tycho Brahe, and what is more, an equatoreal instrument like those "Armillæ aequatoriæ maximæ" with which Tycho observed the comet of 1585 as well as fixed stars and planets.*

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[*] Travaux de la 3e session du congrès international des orientalistes, vol. II.

[†] Souciet, Observations mathématiques, &c., T. II., p. 108.

[‡] Memoirs and Observations Topographical (London, 1697), p. 65.

It is well known that armillæ have been in use in China from a very early date, probably even before the astronomers of Alexandria commenced using instruments with graduated circles. It is particularly stated by Father Gaubil that Sse-Ma-Tsien about the year 100 B.C. mentions some *old* instruments with circles of two feet five inches diameter. It is added that the motions of the stars were referred to the equator, and that there was no instrument in use for observing the motion on the ecliptic. This would seem to indicate that the Chinese astronomers, who in so many respects were behind the Greeks in their knowledge, had actually invented equatoreal armillæ (which were not in use in Europe before Tycho Brahe) and used them instead of the less convenient and unsymmetrical "armillæ zodiacales" invented by Hipparchus, and still used even by Walther and Regiomontanus. But even admitting that the description of these old instruments is much too vague to establish a claim for the Chinese astronomers of the time before Christ, as being the inventors of the equatoreal armillæ; at any rate it is now certain that Ko Show-King, the astronomer of Koblai Khan, constructed such armillæ 300 years before Tycho Brahe. It has been suspected by the younger Sédillot† that Alhazen was acquainted with equatoreal armillæ, but even if this was really the case, it would probably be carrying conjecture too far to suppose the Mongol astronomer as having heard of this occidental invention.

The instruments of Ko Show-King were examined in one of the first years of the seventeenth century by the Jesuit Matteo Ricci (who died in China in 1610),‡ who speaks of them as being counterparts of some he had seen at Nanking, and described at some length. Mr. Wylie (l.c. p. 18), quotes the following part of this description from Colonel Yule's translation in "The Book of Ser Marco Polo" (vol. II.). "A second instrument was a great sphere, not less in diameter than that measure of the outstretched arms which is commonly called a geometric pace. It had a horizon and poles; instead of circles it was provided with certain double hoops, the void space between the pair serving the purpose of the circles of our spheres. All these were divided into 365 degrees and some odd minutes.§ There was no globe to represent the earth in the centre, but there was a certain tube, bored like a gun-barrel, which could readily be turned about and fixed to any azimuth or any altitude, so as to observe any particular star through the tube, just as we do with our vane-sights." . . .

This description evidently refers to an imitation of the equatoreal armillæ now in the courtyard of the Peking observatory. The photograph shows in fact very distinctly that all the circles are double, separated by a narrow interval. Whether this interval was intended for the hollow tube to slide in, or whether the circles were only made double in order to strengthen the instrument, it is not easy to see, perhaps both these objects were kept in view. The tube appears to have four longitudinal slits in it 90° apart, and interrupted near the middle of the tube; but what they were intended for, I cannot make out.

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* Astr. inst. Mechanica, fol. D. 2.

† Prolégomènes des Tables astronomiques d'Olough-Beg, Paris, 1847, p. cxxxiv.

‡ Jöcher's Gelehrten Lexicon, vol. III.

§ It will be remembered that the Chinese divided the circle into 365¼°.

The other instrument of Ko Show-King, the *Keen e*, which I have above likened to Tycho Brahe's Armillæ maximæ, and which is by far the more interesting of the two, is described at great length in the *Yuen-she.* It consists of a double declination circle six feet in diameter, each circle two inches wide and an inch in thickness. The interval between the two circles is one inch, and they are connected at four points 90° apart. "The degrees and minutes" are marked round the circumference (Father Matteo says, by prominent studs of iron which could be felt in the dark). There is no polar axis, but two parallel stretchers four inches on either side of the polar pivots, and joined in the middle by a transversal brace, in the middle of which is the pivot for the alhidade. The latter has pointed ends and two sights with a round aperture in the middle, three-fifths of an inch in diameter, "with a fiducial line down the centre." The south pivot of the declination circle is in the centre of an immovable "diurnal circle" of the same size, divided into twenty-four hours, and let into the supports of the instrument. On this slides a revolving equatoreal circle of exactly the same size, "divided into degrees and minutes, according to the twenty-eight constellations." The latter is also furnished with an alhidade like the declination circle. Then we read in the *Yuen-she* the following passage which I copy verbatim from Mr. Wylie's translation (l.c. p. 14): "A hole is made through the centre of the north-pole pivot; at the bottom of this hole a transverse hole is drilled from side to side. A thread is passed up the centre, bent over and brought out at the two transverse holes, and fastened at both sides. Three lengths of thread are passed through the hole and fastened. At the upper and lower ends, respectively, threads are carried down to the two ends of the index bars,* and passed through a hole, being sunk into the under side of the index bar, along the centre line of which a groove is cut to receive the thread. It is then carried along the middle of the slit to the centre of the index bar, and through a hole in the middle part, the thread is passed up from the lower side of the index bar and fastened."

This thread or wire has probably disappeared from the instrument centuries ago.

Mr. Wylie's paper contains two lithographs of the two instruments, but not seen from a good point of view, and consequently not showing all the details well. I trust the reader will have learned sufficient from the above descriptions to acknowledge the historical interest attached to these old instruments, which anticipated some of the ideas of the great Danish astronomer three centuries before his time.

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* i.e., the alhidade.

RECENT LITERATURE.

"*Variable Stars of Short Period,*" *by Edward C. Pickering* (Proc. Amer. Acad., Vol. XVI., 28 pp.).—This paper forms a continuation of the paper on variables of the Algol Type and deals with stars like β Lyræ and δ Cephei, whose light is continually varying, but so that the changes are repeated with great regularity in a period not exceeding a few days. The Author considers the variation of a star of short period to be, most probably, due to rotation round its axis, the difference in brightness of the two sides of a star being either caused by spots like those on our Sun, by large dark patches, or by a difference in temperature. A great part of the paper is taken up with a comparison of the light-curves of stars of this class and the equation—

$$L = a + b \sin v + c \cos v + d \sin 2v + e \cos 2v,$$

where a is the mean light, v the angle of rotation, and b, c, d, and e constants depending on the brilliancy and form of the star, which may, possibly, not be a solid of revolution.

Professor Pickering remarks, that if we admit a common origin of the stars of the Milky Way, a general coincidence in their axes of rotation seems not improbable, especially as such an approximate coincidence occurs in the members of the Solar System. If the coincidence were exact, the direction must be that of the poles of the Sun, or, approximately, that of the pole of the Ecliptic. On the other hand, since the stars of the Milky Way are supposed to be arranged in the general form of a flattened disk, we should more naturally expect that the axes of rotation would be symmetrically situated with regard to it, or would coincide with its shortest dimension. According to this theory the axes of rotation would be directed towards the poles of the Milky Way. If we suppose that a great number of variable stars were distributed over the heavens, it is evident that those seen in the direction of their axes would not appear to vary, since, as they turned, they would always present the same portions of their surfaces to the observer. Those at right angles to this direction would show the greatest variation and would appear to be more numerous, since they would be more likely to be detected. If then the axes are coincident, we should expect that most of these variable stars would lie along the arc of a great circle whose pole would coincide with their axes of rotation. The stars of the class considered were plotted on a map. They were eighteen in number (seven red stars having been excluded as probably belonging to a different class, like o Ceti and χ Cygni), and their periods lie between less than a day and 54 days. None of these are more than 16° from a great circle whose pole is in R.A. 13^h and Dec. + 20°, and with two exceptions none are more distant than 10°. This great circle is very nearly coincident with the Milky Way, the pole of which is nearly in R.A. $12^h\cdot7$, Dec. + 28°.

T

"*Bibliographie générale de l'Astronomie, par J. C. Houzeau et A. Lancaster.*" Of this excellent work, Part 3 of the second volume has just appeared, containing columns 849 to 1536. It deals with practical astronomy (instruments), monographs on the bodies of the solar system, and stellar astronomy. Like the two preceding parts it appears to be remarkably complete (for instance, sixty-four columns are taken up by an index of lunar objects, with references to all the books, maps, and papers where they are mentioned), and we have no doubt that anyone will be able, without difficulty, to find any information he may require.

"*Observations on Jupiter, by L. Trouvelot*" (Proc. Amer. Acad., vol. xvi., 23 pp.). In 1876 the Author commenced making drawings of the principal planets, and in this paper he describes his observations of twelve spots on Jupiter and their results as to the rotation of the planet, reserving his other observations for publication whenever means shall be found for publishing the drawings. Mr. Trouvelot puts together in a table the approximate periods of rotation resulting from the observations of each spot. These vary from $9^h\ 55^m\cdot6$ to $9^h\ 47^m$, the great red spot giving the largest result, $9^h\ 55^m\ 38^s\cdot57$ from 2108 rotations. It is remarkable that the period of the red spot, greater at first, has decreased afterwards, and then again increased so as to be very nearly equal to what it was at first. In 1876 the surface of the planet was in an extraordinary state of disturbance, hardly one spot or marking remaining from one day till the next; on May 25 Mr. Trouvelot saw an angular mark on the south side of the equatoreal border cross the disk of Jupiter in less than an hour's time.

Spectrum of Lalande 13412." In "Science," No. 41, Professor Pickering writes that this spectrum belongs to the same class as those of Oeltzen 17681 and the three stars in Cygnus having bright lines. Besides the yellow and blue bands it has a marked line in the green, which is faint or wanting in the other stars. The star is also about a magnitude brighter than the others, and is the only known object of its kind within the reach of small telescopes. The position for 1880 is $6^h\ 49^m\cdot3 - 23°\ 47'$.

A Lost Comet. Mr. Barnard, of Nashville, Tennessee, announced in "Science," No. 47, the discovery of a very faint comet on the morning of May 12, 1881, in $22^h\ 59^m\cdot3 + 14°\ 24'$ in the field with α Pegasi. No motion was detected from three till four o'clock. The following morning it had disappeared from the place but was found again as daylight was whitening the sky, very closely north following α Pegasi, and only visible when the bright star was hidden by the ring-micrometer. Position: $22^h\ 58^m\cdot9 + 14°\ 36'$. No doubt now remaining that it was a comet, Mr. Barnard telegraphed to Mr. Swift, but neither he nor the discoverer could find it on the morning of the 14th or afterwards. Careful search has since been made at Boston, Cambridge, Clinton, and in other places, but without success.

COMET *b* 1881.

The Dun Echt circulars Nos. 19–21 contain the following particulars :

No. 19. Telegram transmitted by Professor Krüger—

> "Buenos Aires, June first. Eighteen hundred koen [seven] comet fi [five] hours south thirty degrees Gould."

No. 20. Telegram from the Astronomer Royal, June 8—

> "Clarkson telegraphs this morning from Kimberley, six thirty yesterday Nucleus ascension five hours eight declination Tuesday [twenty] nine."

This telegram was sent from Kimberley on the 2nd, but was delayed in transmission.

In the *Comptes Rendus,* T. xcii., No. 23, there are two telegrams from H. M. the Emperor of Brazil—

> "31 mai 1881. Comète par Cruls, 29 mai, ascension droite $5^h\ 2^m$, declinaison sud 31° 15′, mouvement nord."

> "Éléments approchés de la comète : Passage au périhélie 30 mai ; distance périhélie 0·8301, longitude périhélie 235·5, longitude noeud 262·02, direct."

Again in No. 24—

> "Rio Janeiro, 9 Juin 1881. Éléments plus approchés de la comète : passage au périhélie, 19 Juin, distance périhélie 0·693, longitude du périhélie 272°, longitude du noeud 273°, inclinaison 64°."

From these elements Mr. Lohse computed the following Ephemeris for Berlin Midnight (Dun Echt Circular, No. 21, June 22)—

		α	δ	log r	log Δ
1881.	June 21,	$5^h\ 23^m$	+ 30° 27′	9·8415	9·5207
	„ 25,	34	46 56	9·8476	9·5624
	„ 29,	49	59 9	9·8591	9·6291
	July 3,	6 11	67 20	9·8752	9·7004

The comet was seen on June 22 by many observers as a very conspicuous object near the northern horizon. On the 25th the correction to the above ephemeris was $+ 10^m + 6^{\circ}{\cdot}2$. At Dunsink the comet was first seen on the 23rd, but clouds prevented observations until the 27th, when it was observed with the meridian-circle and the equatoreal. Owing to the coincident perihelion and node and the great inclination, the remainder of the apparition will be visible in our latitudes, but the brightness is already rapidly decreasing.

Dun Echt Circular, No. 23 (June 27) :—The following particulars respecting the Comet have been received, within the compass of seventeen words, from the "Science Observer," Boston, U. S., by the system devised by Messrs. S. C. Chandler Jr. and J. Ritchie Jr., for the transmission of astronomical data.

From observations made at Harvard College, Messrs. Chandler and Wendell have derived these elements and ephemeris:—

Elements.

T = 1881 June 16·40 Greenwich M. T.
π = 265° 8′
☊ = 270 59 Mean Equinox 1881.
i = 63 31
log q = 9·8657
Direct.

Ephemeris for Washington Midnight.

1881		α			δ	
June 30	6ʰ	14ᵐ	36ˢ		+ 68°	41′
July 4	6	54	28		75	32
8	7	52	16		79	36
12	9	6	0		81	38

On June 24, Dr. Huggins obtained with one hour's exposure a photograph on a gelatine plate of the more refrangible part of the spectrum. It shows a pair of bright lines a little beyond H, in the ultra-violet, which appear to belong to the spectrum of carbon (in some form). There is also a continuous spectrum in which some Frauenhofer lines are visible.

In the meeting of the Paris Academy of Sciences on June 27, M. Janssen exhibited the cliché of a photogram of the comet taken at Meudon, on which stars are seen through the tail. M. Janssen took several photograms of the Nucleus with various exposures, which show that it was not brighter than a star of the fifth magnitude. ("Nature," June 30.)

At Greenwich the comet was observed with the half-prism spectroscope, using a dispersive power equivalent to that of four prisms of 60°. The head showed a bright continuous spectrum with four bright bands. Measures of the principal band in the green showed it to be coincident with the band in the first spectrum of carbon (blue base of flame) at 5165, and not with that in the second spectrum (vacuum-tube) at 5198. The bands in the yellow and the blue (and probably the one in the violet) were also found to be coincident with bands in the first spectrum of carbon. ("The Observatory," No. 51.)

The observations made at Dun Echt and Dunsink are deferred till the next number.

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ON γ VIRGINIS CONSIDERED AS A REVOLVING DOUBLE-STAR.

BY W. DOBERCK.

The binary star γ Virginis may fairly be considered one of the most interesting objects in the heavens. While generally presenting the appearance of two bright stars widely separated, it is sometimes, even in the best telescopes, seen as a single star, the image of one component covering that of the other. Thus, this system forms a striking exception to the rule that large excentricities are associated with large periods of revolution, for though at first this latter was thought to be over six centuries it has since been proved to be less than two. As might be expected it has been well attended to by observers, but the extensive material thus accumulated has but very partially been used for the investigation of the orbit. Some account of the way in which I have proceeded in my calculations may therefore not be superfluous.

I commenced my investigations by drawing two interpolating curves with the angles θ_o and distances ρ_o, as ordinates, taking the epochs as abscissæ. The part of the interpolating curve which it is possible to construct has two points of contrary flexure, whose tangents are almost perpendicular to each other. The curve for the distances has a point about 1836, that in the drawing is not to be distinguished from a cusp, before and after which the distance increases, at first quickly, then more slowly. The angles θ_t and distances ρ_t read off on these curves are exhibited in the second and third columns of Table I., the fourth column of which contains the quantity—

$$\kappa = \tfrac{1}{2}\rho^2 \frac{d\theta}{dt}$$

as calculated from them. I finally adopted $\sqrt{\kappa} = 3{\cdot}44$, and then computed—

$$\rho_\theta = 3{\cdot}44 \sqrt{\frac{dt}{d\theta_t}}$$

as shown in the sixth column. These proved that W. Struve's distances were nearly correct, and the ρ_t 1820–1830, given in the third column, have, therefore, been derived by allowing great weight to his distances. The fifth column shows the angles resulting from the observed distances—

$$\theta_\rho = 11{\cdot}81 \int_o^t \frac{d\theta}{\rho_t^2} + \theta_o$$

where for 1820–1835 the angle corresponding to the epoch 1830·0 is $\theta_o = 265^\circ{\cdot}57$, and for 1838–1880 the angle corresponding to the epoch 1850·0 is $\theta_o = 358^\circ{\cdot}60$. Between 1720 and 1820 I had to depend exclusively upon the interpolated angles and the distances computed from them.

TABLE I.

Epoch	θ_i	ρ_i	κ	θ_ρ	ρ_θ
1720	330°·4	6″·64			
30	327·6	6·40			
40	324·6	6·28			
50	321·5	6·19			
60	318·5	6·08			
70	315·2	5·82			
80	311·4	5·48			
90	307·1	4·98			
1800	301·8	4·45			
1810	295·1	3·85			
1820	285·5	3·20	10·2	285°·4	3″·22
21	284·3	3·08	11·4	289·2	3·08
22	283·0	2·96	11·8	282·9	2·95
23	281·6	2·84	12·1	281·5	2·81
24	280·0	2·72	12·6	279·9	2·68
1825	278·2	2·59	12·7	278·2	2·54
26	276·2	2·44	12·5	276·3	2·41
27	274·0	2·29	12·1	274·1	2·26
28	271·6	2·13	11·5	271·7	2·10
29	268·9	1·97	12·1	268·9	1·93
1830	265·4	1·79	12·8	265·6	1·73
31	260·9	1·60	14·2	261·8	1·52
32	254·3	1·39	14·8	256·2	1·30
33	245·6	1·17	14·0	248·5	1·08
34	233·9	0·93	15·0	237·7	0·85
1835	210·7	0·67	12·3		0·63
36	179·0	0·40			0·38
37	93·0	0·47			0·44
38	62·5	0·74	13·9	67·6	0·69
39	42·2	0·98	15·3	43·8	0·92
1840	30·5	1·20	14·1	30·7	1·14
41	22·6	1·42	13·5	22·9	1·36
42	17·1	1·64	12·4	17·5	1·57
43	13·4	1·84	12·0	13·8	1·78
44	10·0	2·03	12·7	10·4	1·97
1845	7·2	2·21	12·7	7·7	2·15
1845	7°·2	2″·21	12·7	7°·7	2″·15
46	4·8	2·37	12·4	5·5	2·32
47	2·8	2·52	12·0	3·5	2·48
48	1·0	2·65	11·2	1·7	2·63
49	359·6	2·77	10·7	0·1	2·77
1850	358·2	2·88	11·2	358·6	2·90
51	356·9	2·99	11·6	357·2	3·02
52	355·6	3·10	12·0	355·9	3·13
53	354·4	3·21	11·3	354·7	3·24
54	353·4	3·32	11·0	353·6	3·35
1855	352·4	3·42	11·1	352·6	3·46
56	351·5	3·52	11·8	351·6	3·56
57	350·6	3·62	12·5	350·7	3·65
58	349·7	3·71	13·1	349·8	3·74
59	348·8	3·80	12·3	348·9	3·83
1860	348·0	3·89	11·4	348·1	3·92
61	347·3	3·98	11·1	347·4	4·01
62	346·6	4·06	11·6	346·7	4·10
63	345·9	4·13	11·1	346·0	4·19
64	345·3	4·20	10·6	345·3	4·28
1865	344·7	4·27	10·9	344·6	4·37
66	344·1	4·34	11·3	343·9	4·46
67	343·5	4·41	11·6	343·3	4·54
68	342·9	4·48	12·0	342·7	4·62
69	342·3	4·54	11·3	342·1	4·70
1870	341·8	4·60	10·6	341·6	4·78
71	341·3	4·66	10·8	341·0	4·85
72	340·8	4·72	11·1	340·5	4·93
73	340·3	4·77	11·3	340·0	5·00
74	339·8	4·82	10·5	339·4	5·06
1875	339·4	4·87	9·5	338·9	5·12
76	339·0	4·92	9·7	338·3	5·18
77	338·6	4·97	9·9	337·8	5·23
78	338·2	5·02	10·1	337·3	5·28
79	337·8	5·07	10·3	336·8	5·33
1880	337·4	5·12	10·5	336·2	5·37

Table II. exhibits the distances ρ_i and ρ_θ with the angles corresponding to them as argument. Between 337° and 343° ρ_θ is evidently too large, owing to the smallness of $\frac{d\theta}{dt}$. The time was only introduced above in order the more effectually to correct errors of observation. We might, in fact, project the observed distances with the angles as abscissæ. I did not in the present instance find occasion to compute the angle which the tangent makes with the line perpendicular to the radius vector—

$$\psi = \frac{1}{\rho}\frac{d\rho}{d\theta}$$

[TABLE II.

TABLE II.

θ	ρ_i	ρ_θ	θ	ρ_i	ρ_θ	θ	ρ_i	ρ_θ
0°	2″·78	2″·72	235°	0″·88	0″·88	309°		5″·22
1	2·70	2·63	245	1·06	1·07	312		5·55
2	2·62	2·56	249	1·18	1·15	315		5·84
3	2·55	2·47	253	1·30	1·26	318		6·04
4	2·48	2·39	257	1·42	1·40	321		6·17
5	2·41	2·30	261	1·58	1·55	324		6·26
10	2·01	1·97	265	1·77	1·71	327		6·37
15	1·72	1·67	269	1·98	1·89	330		6·52
20	1·52	1·46	271	2·08	2·05	337	5″·05	5·42
25	1·37	1·31	273	2·21	2·20	339	4·86	5·17
30	1·26	1·19	275	2·35	2·32	341	4·66	4·90
35	1·16	1·08	277	2·49	2·45	343	4·45	4·61
40	1·06	0·98	279	2·64	2·60	345	4·23	4·31
45	0·96	0·88	281	2·80	2·76	347	4·01	4·05
55	0·86	0·77	283	2·97	2·95	349	3·79	3·82
65	0·76	0·67	285	3·16	3·17	351	3·58	3·61
93	0·47	0·44	294		3·78	353	3·38	3·40
179	0·40	0·38	297		4·02	355	3·19	3·20
205	0·62	0·59	300		4·28	357	3·01	3·01
215	0·70	0·66	303		4·56	359	2·85	2·82
225	0·78	0·75	306		4·87	360	2·78	2·72

In order to decide between these two curves I projected the points of both and adopted the ellipse that most nearly reconciled them. From the elements of this—the apparent orbit—the elements Ω, λ, γ and e of the real orbit were calculated. Taking a mean of the two θ curves I then calculated, by the aid of these elements, the mean anomalies m_o corresponding to nine epochs. From Bradley's angle 330°·8 in 1718, and Dembowski's 343°·6 in 1867, I obtained a first approximation to P and $\mathrm{T:P} = 177^{\text{yrs}}$, $\mathrm{T} = 1837{\cdot}48$, from which result the mean anomalies m_c. Allowing some small weight to the observations made at the commencement of last century, I then formed the following equations of condition in which Δm is expressed in parts of 20° and Δn in degrees:—

$$
\begin{array}{llrlr|rlrlrlrl}
1718{\cdot}20 & m_o = & 242^\circ{\cdot}64 & m_c = & 242^\circ{\cdot}61 & +\ 4 & \Delta m & +\ 23{\cdot}9 & \Delta n & +\ 0{\cdot}0 & = & +\ 6^\circ{\cdot}81 & \times \frac{1}{5} \\
1738{\cdot}25 & & 186{\cdot}01 & & 201{\cdot}79 & +\ 4 & & +\ 19{\cdot}9 & & +\ 3{\cdot}2 & = & -\ 9{\cdot}83 & \times \frac{1}{5} \\
1795{\cdot}78 & & 81{\cdot}55 & & 84{\cdot}80 & +\ 6\frac{2}{3} & & +\ 13{\cdot}9 & & +\ 1{\cdot}1 & = & +\ 0{\cdot}42 & \times \frac{1}{3} \\
1820{\cdot}0 & & 32{\cdot}51 & & 35{\cdot}54 & +\ 20 & & +\ 17{\cdot}5 & & +\ 3{\cdot}0 & = & -\ 0{\cdot}32 & \\
1830{\cdot}0 & & 12{\cdot}96 & & 15{\cdot}21 & +\ 20 & & +\ 7{\cdot}5 & & +\ 2{\cdot}3 & = & +\ 0{\cdot}07 & \\
1840{\cdot}0 & & 353{\cdot}53 & & 354{\cdot}87 & +\ 20 & & -\ 2{\cdot}5 & & +\ 1{\cdot}3 & = & +\ 0{\cdot}58 & \\
1850{\cdot}0 & & 332{\cdot}78 & & 334{\cdot}54 & +\ 20 & & -\ 12{\cdot}5 & & +\ 1{\cdot}8 & = & -\ 0{\cdot}23 & \\
1860{\cdot}0 & & 312{\cdot}68 & & 314{\cdot}20 & +\ 20 & & -\ 22{\cdot}5 & & +\ 1{\cdot}5 & = & -\ 0{\cdot}39 & \\
1870{\cdot}0 & & 293{\cdot}31 & & 293{\cdot}85 & +\ 20 & & -\ 32{\cdot}5 & & +\ 0{\cdot}5 & = & +\ 0{\cdot}18 &
\end{array}
$$

I found it impossible, however, to reconcile the old observations with the modern measures, and had, therefore, to exclude them both. To make use of such data for calculating the motion of a double-star is, in fact, as much out of place as it would be to take Tycho Brahe's observations into account in forming a modern catalogue of stars. When these were excluded I obtained $\Delta m = -2^\circ{\cdot}022$ and $\Delta n = -0^\circ{\cdot}0398$, or $\mathrm{T} = 1836{\cdot}466$, and $\mathrm{P} = 180^{\text{yrs}}{\cdot}54$. The remaining errors $m_o - m_c$ are already entered above. The value of the semi-axis major, $a = 4''{\cdot}09$ was obtained from ρ_i from 1850 to 1880.

These elements are exhibited in Table V., and their comparison with the observations $\theta_o - \theta_1$ and $\rho_o - \rho_1$ in Table VI.

From the $\theta_o - \theta_1$ exhibited in this Table the normal places in Table III. were formed. The first column shows the epoch, the second the normal position-angle corresponding to this, the third the average $\theta_o - \theta_1$, the fourth the number of observations n, and the fifth the weight w attributed to the respective $\theta_o - \theta_1$:—

TABLE III.

Epoch	θ_o	$\theta_o - \theta_1$	n	w
1795·78	303°·73	+ 0°·53	3	$\frac{1}{2}$
1827·50	272·23	− 0·62	17	$\frac{3}{4}$
1834·00	230·01	− 9·81	21	$\frac{1}{2}$
1838·00	56·87	+ 3·80	24	$\frac{3}{4}$
1845·00	7·57	− 0·25	44	$\frac{7}{4}$
1852·50	354·93	− 0·39	37	$\frac{3}{2}$
1857·50	350·31	+ 0·06	40	2
1865·00	344·61	− 0·02	45	2
1872·50	340·69	+ 0·34	31	$\frac{3}{2}$
1877·00	338·20	+ 0·07	26	$\frac{3}{2}$

I then calculated the differential coefficients $\frac{d\theta}{de}$ and $\frac{d\theta}{d\gamma}$. The first by slightly increasing the excentricity, the second by varying the inclination 10° on either side and taking the mean. I thus obtained the following equations of condition:—

$$
\begin{array}{rlrlrlrcl|rr}
+\ 3^\circ & & +\ \cdot 0478 & & +\ 10^\circ & & & & & & \\
+\ 1\cdot00 & \Delta\Omega & +\ 0\cdot76 & \Delta e & -\ 0\cdot56 & \Delta\gamma & -\ 0^\circ\cdot18 & = & 0 & \theta_o - \theta_{\rm I} = +\ 2^\circ\cdot06 & \theta_o - \theta_{\rm II} = +\ 0^\circ\cdot46 \\
+\ 2\cdot70 & & +\ 5\cdot28 & & -\ 3\cdot43 & & +\ 0\cdot56 & = & 0 & +\ 2\cdot26 & -\ 0\cdot25 \\
+\ 2\cdot10 & & +\ 6\cdot17 & & -\ 1\cdot23 & & +\ 6\cdot87 & = & 0 & -\ 3\cdot96 & [-\ 7\cdot36] \\
+\ 2\cdot70 & & -\ 8\cdot71 & & -\ 0\cdot85 & & -\ 3\cdot42 & = & 0 & -\ 1\cdot50 & -\ 0\cdot56 \\
+\ 4\cdot00 & & -\ 7\cdot51 & & +\ 5\cdot04 & & +\ 0\cdot33 & = & 0 & -\ 1\cdot41 & -\ 1\cdot01 \\
+\ 3\cdot75 & & -\ 5\cdot21 & & +\ 4\cdot70 & & +\ 0\cdot49 & = & 0 & -\ 0\cdot67 & -\ 0\cdot60 \\
+\ 4\cdot20 & & -\ 5\cdot11 & & +\ 5\cdot04 & & -\ 0\cdot08 & = & 0 & +\ 0\cdot08 & -\ 0\cdot02 \\
+\ 4\cdot20 & & -\ 4\cdot19 & & +\ 4\cdot58 & & +\ 0\cdot03 & = & 0 & +\ 0\cdot26 & -\ 0\cdot02 \\
+\ 3\cdot75 & & -\ 3\cdot07 & & +\ 3\cdot68 & & -\ 0\cdot43 & = & 0 & -\ 0\cdot82 & +\ 0\cdot42 \\
+\ 3\cdot75 & & -\ 2\cdot75 & & +\ 3\cdot44 & & -\ 0\cdot09 & = & 0 & +\ 0\cdot58 & +\ 0\cdot13
\end{array}
$$

From these follow the normal equations:—

$$
\begin{array}{rlrlrlrcl}
+\ 113\cdot5 & \Delta\Omega & -\ 105\cdot8 & \Delta e & +\ 90\cdot1 & \Delta\gamma & +\ 7\cdot5 & = & 0 \\
-\ 105\cdot8 & & +\ 286\cdot7 & & -\ 146\cdot7 & & +\ 71\cdot8 & = & 0 \\
+\ 90\cdot1 & & -\ 146\cdot7 & & +\ 133\cdot5 & & -\ 5\cdot55 & = & 0
\end{array}
$$

Which give: $\Delta\Omega = -0\cdot283 \times 3^\circ$, $\Delta e = -0\cdot539 \times 0.0478$ and $\Delta\gamma = -0\cdot3601 \times 10^\circ$, and these corrections, when applied to the elements, leave the errors $\theta_o - \theta_{\rm I}$ shown above. From these it appears that the third normal place, which evidently suffers from constant errors, has vitiated the representation of the other data. I therefore excluded it and then obtained the normal equations:—

$$
\begin{array}{rlrlrlrcl}
+\ 109\cdot0 & \Delta\Omega & -\ 118\cdot8 & \Delta e & +\ 92\cdot7 & \Delta\gamma & -\ 6\cdot9 & = & 0 \\
-\ 118\cdot8 & & +\ 248\cdot6 & & -\ 139\cdot1 & & +\ 29\cdot4 & = & 0 \\
+\ 92\cdot7 & & -\ 139\cdot1 & & +\ 132\cdot0 & & +\ 2\cdot9 & = & 0
\end{array}
$$

Which give: $\Delta\Omega = +0\cdot060 \times 3^\circ$, $\Delta e = -0\cdot3070 \times 0\cdot0478$ and $\Delta\gamma = -0\cdot3854 \times 10^\circ$, which, when applied to the elements, leave the outstanding errors, $\theta_o - \theta_{\rm II}$ as shown in the same place.

With the elements thus corrected I calculated the differential coefficients: $\frac{d\theta}{d\lambda}$, $\frac{d\theta}{dT}$, and $\frac{d\theta}{dn}$, and obtained the equations of condition:—

$$\begin{array}{rlrlrlrl|rr}
+2^{\circ} & & 1^{r} & & +0^{\circ}\!\cdot\!1 & & & & & \\
+0\cdot83 & \Delta\lambda & +0\cdot15 & \Delta T & +0\cdot31 & \Delta n & -0^{\circ}\!\cdot\!15 & =0 & \theta_{o}-\theta_{III}=+2^{\circ}\!\cdot\!7 & \theta_{o}-\theta_{IV}=+0^{\circ}\!\cdot\!91 \\
+1\cdot91 & & +2\cdot25 & & +1\cdot01 & & +0\cdot22 & =0 & +2\cdot3 & -0\cdot22 \\
+1\cdot16 & & +9\cdot24 & & +1\cdot11 & & +5\cdot15 & =0 & -2\cdot9 & [-7\cdot69] \\
+1\cdot46 & & +24\cdot57 & & -1\cdot96 & & +0\cdot50 & =0 & +1\cdot0 & -0\cdot13 \\
+2\cdot61 & & +3\cdot27 & & -1\cdot40 & & +1\cdot35 & =0 & -0\cdot9 & -0\cdot78 \\
+2\cdot62 & & +1\cdot50 & & -1\cdot20 & & +0\cdot75 & =0 & -0\cdot6 & -0\cdot42 \\
+3\cdot05 & & +1\cdot29 & & -1\cdot34 & & +0\cdot02 & =0 & 0\cdot0 & +0\cdot16 \\
+3\cdot20 & & +0\cdot91 & & -1\cdot30 & & +0\cdot02 & =0 & 0\cdot0 & +0\cdot14 \\
+2\cdot88 & & +0\cdot62 & & -1\cdot13 & & -0\cdot52 & =0 & +0\cdot5 & +0\cdot59 \\
+2\cdot92 & & +0\cdot59 & & -1\cdot20 & & -0\cdot16 & =0 & +0\cdot2 & +0\cdot32
\end{array}$$

From these follow the normal equations:—

$$\begin{array}{rlrlrlrl}
+57\cdot8 & \Delta\lambda & +73\cdot8 & \Delta T & -21\cdot2 & \Delta n & +10\cdot6 & =0 \\
+73\cdot8 & & +710\cdot2 & & -46\cdot3 & & +65\cdot3 & =0 \\
-21\cdot2 & & -46\cdot3 & & +15\cdot8 & & +2\cdot84 & =0
\end{array}$$

Which give: $\Delta\lambda = -0\cdot45 \times 2^{\circ}$, $\Delta T = -0\cdot12 \times 1^{r}$ and $\Delta n = -1\cdot13 \times 0^{\circ}\!\cdot\!1$, and these corrections, when applied to the elements, leave the errors $\theta_{o} - \theta_{III}$ shown above. From the same consideration as before I, however, preferred to exclude the third equation and obtained, then, the normal equations:—

$$\begin{array}{rlrlrlrl}
+56\cdot5 & \Delta\lambda & +63\cdot1 & \Delta T & -22\cdot5 & \Delta n & +4\cdot7 & =0 \\
+63\cdot1 & & +624\cdot8 & & -56\cdot5 & & +17\cdot7 & =0 \\
-22\cdot5 & & -56\cdot5 & & +14\cdot6 & & -2\cdot9 & =0
\end{array}$$

Which give: $\Delta\lambda = -0\cdot030 \times 2^{\circ}$, $\Delta T = -0\cdot016 \times 1^{r}$ and $\Delta n = +0\cdot099 \times 0^{\circ}\!\cdot\!1$; subsequently I calculated from the nine normal places a further correction to be applied to the node and found : $\Delta \Omega = +0^{\circ}\!\cdot\!01$.

Adopting the value of the semi-axis major $a = 4''\!\cdot\!09$ deduced above, I computed the distances ρ_1 between the components for every epoch after the periastron passage, and obtained, by the comparison of these with the observed distances, the normal values of the deviations, $\rho_o - \rho_1$ exhibited in the third column of Table IV., and thence the normal value of the distance ρ_o exhibited in the second column. The fourth column shows the number of observations n, and the fifth the weight w.

From these I obtained $a = 3''\!\cdot\!94$, from which I calculated the distances ρ_2 and their deviations from the observations $\rho_0 - \rho_2$, as shown in the sixth and seventh column.

TABLE IV.

Epoch	ρ_0	$\rho_0 - \rho_1$	n	w	ρ_2	$\rho_0 - \rho_2$
1834·0	0″·938	− 0″·054	14	$\frac{1}{5}$	0″·956	− 0″·018
1838·0	0·747	+ 0·017	16	$\frac{1}{7}$	0·703	+ 0·044
1845·0	2·195	− 0·032	42	$\frac{3}{2}$	2·146	+ 0·049
1852·5	3·120	− 0·122	35	$\frac{3}{2}$	3·123	− 0·003
1857·5	3·653	− 0·122	38	2	3·637	+ 0·016
1865·0	4·232	− 0·196	39	3	4·266	− 0·034
1872·5	4·784	− 0·174	27	2	4·777	+ 0·007
1877·0	4·977	− 0·248	26	2	5·034	− 0·057

Employing the symbols introduced by Sir J. Herschel, the elements are exhibited in Table V. and their comparison with the observations, $\theta_0 - \theta_2$ and $\rho_0 - \rho_2$, in Table VI. They confirm the accuracy of the results at which Thiele arrived in 1866, by an able discussion of a smaller number of observations. It will further be remarked that the observations are not better represented by the second orbit than by the first, except those made near the periastron passage; when the companion also quickly passed the meridian.* As was to be expected the measures made while the two bright components were so near each other are very much vitiated by systematic errors, which, as they follow regular laws, cannot be eliminated by aid of the method of least squares, and this is tantamount to saying that systematic errors are not eliminated by merely taking the average of the measures made by many individuals. In fact physiological reasons could be given why the personal errors committed by different experienced observers must have much in common. This is strikingly illustrated by my experience, and has been also recognized by some eminent authorities. It would be idle to presume to determine the amount of the corrections required from a discussion of the observations of a single object however prominent, but that they, to a large extent, are eliminated is shown by the agreement of the column of Table VI. exhibiting $\theta_0 - \theta_\rho$, with the columns showing $\theta_0 - \theta_1$, and $\theta_0 - \theta_2$. I am about to investigate these peculiarities on the basis of more extensive materials, and have in fact already made some progress in this direction. Such researches necessarily demand time, but when they are finished I venture to hope that I shall be able to apply more or less justifiable corrections to the different observations, and what is also much required I shall be able to calculate appropriate weights, which, up to this time, were merely roughly estimated. I therefore defer any further investigations concerning the orbit of γ Virginis, until I shall have the aid of the results of these calculations.

TABLE V.

Orbit of γ Virginis.

First Elements.		Second Elements.
45° 49′	☊	46° 0′
93 59	λ	93 55
37 0	γ	33 9
0·8978	e	0·8904
180^{yrs}·54	P	179^{yrs}·65
1836·47	T	1836·45
4″·09	a	3″·94
− 1°·9940	n	− 2°·0039

---

* The part of the orbit most interesting to discuss was described between 1839 and 1847, when the angle, after being very oblique, passed quickly through zero, while the distance did not alter so very much. The peculiarities of the observers appear here at a glance. Thus, while the correction required by the positions of Dawes, who made use of a prism for keeping the images of the stars apparently in the great circle passing through the zenith, did not much alter, that of O. Struve altered in a most pronounced manner, but it is quite natural that the errors should be rather large in the case of these stars, which for most observers were at no great distance from the southern horizon, and which, in most telescopes, appear as large discs, at least when the state of the atmosphere is not exceptionally favourable. The too large distances with which observers generally commence have their origin in phenomena of irradiation, but it is curious that earlier observers also measured these small distances larger than more modern astronomers. In fact but for W. Struve's measures, that happily form an exception to this rule, we should be rather awkwardly situated.

The two stars are so nearly alike that it appears, hitherto, not to have been decided which is the brighter. At one time it was suspected that one or both were slightly variable. These questions will, most likely, not be answered before a large refractor in the southern hemisphere is devoted to the regular observation of double-stars. In Table VI. I have altered the angle half a circumference wherever required for the sake of uniformity.

TABLE VI.

Observer	Epoch	θ_0	ρ_0	$\theta_0 - \theta_\rho$	$\theta_0 - \theta_1$	$\theta_0 - \theta_2$	$\rho_0 - \rho_1$	$\rho_0 - \rho_2$
Bradley,	1718·20	330°·8	—	—	+ 1°·2	+ 1°·1	—	—
Cassini,	1720·31	319·0	7″·49	—	— 9·8	— 9·9	+ 1″·60	+ 1″·56
Tob. Mayer,	1756·20	324·4	6·50	—	+ 6·7	+ 6·6	+ 0·36	+ 0·30
Chr. Mayer,	1777 ±	310 ±	9·8	—	— 0·4	— 0·5	—	—
W. Herschel,	1780·18	—	4·2	—	—	—	— 1·40	— 1·47
W. Herschel,	1781·89	310·7	—	—	+ 1·6	+ 1·6	—	—
W. Herschel,	1802·08	298·4	—	—	— 1·6	— 1·6	—	—
W. Herschel,	1803·37	300·8	—	—	+ 1·6	+ 1·5	—	—
W. Struve,	1819·40	—	3·56	—	—	—	+ 0·39	+ 0·39
W. Struve,	1820·28	284·9	2·76	— 0°·2	— 0·4	— 0·4	— 0·31	— 0·31
W. Struve,	1822·02	282·8	—	— 0·1	— 0·4	— 0·3	—	—
J. Herschel,	1822·25	283·4	3·79	+ 0·8	+ 0·6	+ 0·7	+ 0·94	+ 0·95
Amici,	1823·19	—	3·30	—	—	—	+ 0·56	+ 0·57
W. Struve,	1823·32	281·6	2·95	+ 0·6	+ 0·5	+ 0·7	+ 0·23	+ 0·24
South,	1825·32	276·9	3·26	— 0·7	— 0·6	— 0·4	+ 0·78	+ 0·80
W. Struve,	1825·32	277·9	2·37	+ 0·3	+ 0·4	+ 0·6	— 0·11	— 0·09
J. Herschel,	1828·35	270·3	—	— 0·5	— 0·2	+ 0·1	—	—
W. Struve,	1828·38	271·5	2·07	+ 0·9	+ 1·1	+ 1·4	+ 0·03	+ 0·05
J. Herschel,	1829·22	267·7	1·79	— 0·5	— 0·2	+ 0·2	— 0·12	— 0·10
W. Struve,	1829·39	268·3	1·78	+ 0·6	+ 1·0	+ 1·4	— 0·11	— 0·09
J. Herschel,	1830·24	262·8	2·22	— 1·9	— 1·7	— 0·9	+ 0·47	+ 0·49
Dawes,	1830·39	261·5	—	— 2·5	— 2·4	— 1·6	—	—
Bessel,	1830·59	262·2	1·59	— 1·2	— 0·9	0·0	— 0·09	— 0·07
Dawes,	1831·30	258·3	1·99	— 1·8	— 1·6	— 0·6	+ 0·44	+ 0·46
J. Herschel,	1831·32	257·2	1·74	— 2·7	— 2·6	— 1·7	+ 0·19	+ 0·21
W. Struve,	1831·36	260·9	1·49	+ 1·1	+ 1·3	+ 2·3	— 0·05	— 0·03
Smyth,	1831·38	254·9	1·6	— 4·7	— 4·6	— 3·6	+ 0·07	+ 0·09
J. Herschel,	1832·27	250·2	1·21	— 4·1	— 4·3	— 2·9	— 0·16	— 0·14
Dawes,	1832·30	249·9	1·33	— 4·0	— 4·5	— 3·1	— 0·03	— 0·02
Cooper,	1832·33	—	1·94	—	—	—	+ 0·59	+ 0·61
Smyth,	1832·40	251·4	1·2	— 1·7	— 2·4	— 0·9	— 0·14	— 0·12
W. Struve,	1832·52	253·5	1·26	+ 1·2	+ 0·5	+ 1·9	— 0·05	— 0·02
J. Herschel,	1833·20	241·8	1·41	— 4·6	— 6·0	— 4·3	+ 0·25	+ 0·27
Smyth,	1833·34	243·1	1·3	— 1·8	— 3·5	— 1·7	+ 0·17	+ 0·19
Mädler,	1833·35	236·4	—	— 8·5	—10·1	— 8·2	—	—
Dawes,	1833·36	240·1	1·14	— 4·4	— 6·3	— 4·6	+ 0·02	+ 0·04
W. Struve,	1833·37	245·5	1·05	+ 1·1	— 0·8	+ 1·0	— 0·07	— 0·05
Dawes,	1834·29	227·3	—		— 8·7	— 5·7	—	—
Smyth,	1834·30	227·1	0·9		— 8·8	— 5·9	+ 0·01	+ 0·02
Mädler,	1834·34	214·8	—		—20·6	—17·6	—	—
J. Herschel,	1834·37	223·1	0·51		—11·9	— 8·9	— 0·37	— 0·35
W. Struve,	1834·38	231·6	0·91		— 3·2	— 0·1	+ 0·04	+ 0·05
J. Herschel,	1834·54	214·9	—		—17·4	—14·2	—	—
W. Struve,	1834·84	213·6	—		—13·1	— 9·6	—	—
J. Herschel,	1835·11	201·4	—		—19·2	—14·9	—	—
W. Struve,	1835·38	195·5	0·51		—17·2	—12·3	— 0·09	— 0·07
Senff,	1835·39	195·2	0·57		—17·1	—12·2	— 0·02	0·00
Smyth,	1835·40	195·0	0·5		—17·2	—12·1	— 0·09	— 0·07
O. Struve,	1835·42	197·1	—		—14·2	— 9·2	—	—

Observer	Epoch	θ_0	ρ_0	$\theta_0 - \theta_p$	$\theta_0 - \theta_1$	$\theta_0 - \theta_2$	$\rho_0 \quad \rho_1$	$\rho_0 - \rho_2$
Dawes,	1836·28	169°·5	—		+10°·0	+14°·2	—	—
Smyth,	1836·35	169·7	—		+17·3	+20·2	—	—
W. Struve,	1836·41	151·6	0″·26		+ 5·0	+ 7·3	—0″·08	— 0″·10
O. Struve,	1836·41	158·2	—		+11·6	+13·9	—	—
Sabler,	1836·41	153·8	—		+ 7·2	+ 9·5	—	—
Encke,	1836·59	113·9	—		—14·0	—14·2	—	—
Mädler,	1836·59	117·5	—		—10·4	—10·6	—	—
Smyth,	1837·21	85·4	0·6		+ 5·4	+ 0·7	+ 0·12	+ 0·12
Mädler,	1837·37	75·5	0·81		+ 2·9	— 1·4	+ 0·28	+ 0·29
O. Struve,	1837·41	77·9	0·58		+ 7·0	+ 2·6	+ 0·04	+ 0·04
Encke,	1837·46	76·3	0·67		+ 7·5	+ 3·1	+ 0·11	+ 0·11
J. Herschel,	1838·08	57·4	—		+ 5·9	+ 2·4	—	—
Smyth,	1838·28	55·7	0·8		+ 7·9	+ 4·5	0·00	+ 0·02
Dawes,	1838·32	53·4	—		+ 6·5	+ 3·0	—	—
Lamont,	1838·36	—	1·24		—	—	+ 0·42	+ 0·43
W. Struve,	1838·40	51·9	0·86		+ 6·4	+ 3·0	+ 0·02	+ 0·04
O. Struve,	1838·43	51·1	0·80		+ 6·1	+ 2·8	— 0·05	— 0·03
Mädler,	1838·44	47·0	0·90		+ 2·2	— 1·1	+ 0·05	+ 0·06
Galle,	1838·46	49·0	0·70		+ 4·5	+ 1·2	— 0·16	— 0·14
Dawes,	1839·31	34·6	1·26		+ 0·3	— 1·9	+ 0·17	+ 0·20
Galle,	1839·35	35·5	1·30		+ 1·6	— 0·6	+ 0·20	+ 0·23
Smyth,	1839·40	37·2	1·0		+ 3·8	+ 1·5	— 0·11	— 0·08
Kaiser,	1840·26	27·9	1·30	—0°·8	+ 1·1	— 0·4	— 0·02	+ 0·03
Dawes,	1840·38	25·7	1·24	— 2·0	— 0·3	— 1·7	— 0·10	— 0·06
O. Struve,	1840·45	31·6	1·42	+ 4·5	+ 6·1	+ 4·6	+ 0·06	+ 0·11
Challis,	1841·19	20·9	1·42	— 1·0	— 0·2	— 1·6	— 0·10	— 0·05
Dawes,	1841·34	20·0	1·58	— 1·1	— 0·4	— 1·7	+ 0·02	+ 0·07
Mädler,	1841·35	20·1	1·73	— 0·9	— 0·2	— 1·5	+ 0·17	+ 0·22
O. Struve,	1841·41	22·4	1·63	+ 1·7	+ 2·3	+ 1·1	+ 0·06	+ 0·11
Mädler,	1842·21	16·6	1·58	— 0·1	0·0	— 0·9	— 0·15	— 0·09
Main,	1842·34	17·4	1·67	+ 1·1	+ 1·4	+ 0·4	— 0·09	— 0·02
Airy,	1842·35	17·6	1·83	+ 1·4	+ 1·6	+ 0·6	+ 0·07	+ 0·14
Challis,	1842·35	12·2	1·85	— 4·0	— 3·8	— 4·8	+ 0·09	+ 0·16
Dawes,	1842·38	14·9	1·73	— 1·2	— 1·0	— 2·0	— 0·04	+ 0·03
O. Struve,	1842·41	17·1	1·86	+ 1·1	+ 1·3	+ 0·4	+ 0·09	+ 0·15
Kaiser,	1842·82	14·5	1·76	0·0	+ 0·2	— 0·7	— 0·09	— 0·02
Mädler,	1842·88	14·7	1·84	+ 0·5	+ 0·7	— 0·2	— 0·03	+ 0·05
Challis,	1843·30	0·7	2·05	—12·1	—12·0	—12·7	+ 0·10	+ 0·19
Mädler,	1843·35	12·1	—	— 0·5	— 0·4	— 1·1	—	—
Main,	1843·39	13·6	2·08	+ 1·2	+ 1·2	+ 0·5	+ 0·12	+ 0·20
Dawes,	1843·40	12·2	1·82	— 0·2	— 0·2	— 0·9	— 0·15	— 0·06
Encke,	1843·48	11·4	2·45	— 0·7	— 0·7	— 1·4	+ 0·47	+ 0·55
Challis,	1844·33	9·0	2·63	— 0·5	— 0·6	— 1·2	+ 0·49	+ 0·59
Richardson,	1844·34	2·9	2·20	— 6·6	— 6·7	— 7·2	+ 0·06	+ 0·15
Mädler,	1844·36	8·9	—	— 0·5	— 0·7	— 1·2	—	—
Encke,	1844·38	8·6	2·27	— 0·7	— 0·9	— 1·4	+ 0·12	+ 0·22
Encke,	1845·28	8·9	2·41	+ 1·8	+ 1·6	+ 1·2	+ 0·12	+ 0·22
Smyth,	1845·34	5·4	2·10	— 1·6	— 1·7	— 2·1	— 0·20	— 0·10
Mädler,	1845·37	7·0	—	+ 0·2	0·0	— 0·4	—	—
O. Struve,	1845·46	4·5	2·23	— 2·1	— 2·3	— 2·7	— 0·09	+ 0·01
Hind,	1846·28	5·0	—	0·0	0·0	— 0·4	—	—
Jacob,	1846·32	2·2	2·89	— 2·7	— 2·7	— 3·1	+ 0·46	+ 0·54
Main,	1846·39	6·3	2·25	+ 1·6	+ 1·6	+ 1·2	— 0·19	— 0·11
O. Struve,	1846·39	2·9	2·35	— 1·8	— 1·8	— 2·2	— 0·09	— 0·01
Mitchel,	1846·49	4·1	1·83	— 0·4	— 0·4	— 0·8	— 0·61	— 0·54
Dawes,	1846·90	3·7	2·45	0·0	+ 0·1	— 0·2	— 0·06	— 0·02
Hind,	1847·07	1·9	2·62	— 1·5	— 1·4	— 1·7	+ 0·09	+ 0·17
Dawes,	1847·35	2·5	2·40	— 0·4	— 0·2	— 0·5	— 0·16	— 0·09
Main,	1847·41	13·0	2·37	+10·2	+10·4	+10·1	— 0·20	— 0·12
Smyth,	1847·42	1·9	2·6	— 0·9	— 0·7	— 1·0	+ 0·03	+ 0·11
O. Struve,	1847·42	2·5	2·40	— 0·3	— 0·1	— 0·4	— 0·17	— 0·09
Mitchel,	1847·56	2·5	3·09	+ 0·1	+ 0·1	— 0·2	+ 0·50	+ 0·58

Observer	Epoch	θ_0	ρ_0	$\theta_0 - \theta_\rho$	$\theta_0 - \theta_1$	$\theta_0 - \theta_2$	$\rho_0 - \rho_1$	$\rho_0 - \rho_2$
Jacob,	1847·94	359°·9	2″·88	—1°·9	—1°·7	—2°·0	+0″·25	+0″·32
Mädler,	1848·34	360·8	2·71	— 0·4	— 0·2	— 0·5	+ 0·03	+ 0·10
Smyth,	1848·36	359·5	2·8	— 1·6	— 1·4	— 1·7	+ 0·12	+ 0·18
Dawes,	1848·37	360·6	2·62	— 0·5	— 0·3	— 0·6	— 0·06	0·00
O. Struve,	1848·43	359·1	2·55	— 1·9	— 1·8	— 2·1	— 0·13	— 0·07
Bond,	1848·45	360·4	2·6	— 0·5	— 0·4	— 0·7	— 0·09	— 0·03
Mitchel,	1848·45	360·6	2·80	— 0·3	— 0·2	— 0·5	+ 0·11	+ 0·17
Main,	1848·48	360·5	2·60	— 0·4	— 0·3	— 0·5	— 0·09	— 0·03
Dawes,	1849·37	359·0	2·85	— 0·5	— 0·5	— 0·6	+ 0·06	+ 0·11
O. Struve,	1849·41	352·9	2·64	— 6·6	— 6·5	— 6·7	— 0·15	— 0·11
Bond,	1849·45	359·8	3·0	+ 0·3	+ 0·4	+ 0·3	+ 0·20	+ 0·24
Main,	1849·50	357·0	2·92	— 2·3	— 2·3	— 2·4	+ 0·12	+ 0·15
Johnson,	1850·23	359·7	2·85	+ 1·4	+ 1·4	+ 1·3	— 0·04	— 0·01
Hartnup,	1850·30	357·5	2·90	— 0·7	— 0·7	— 0·8	+ 0·01	+ 0·03
Fletcher,	1850·36	356·7	2·95	— 1·3	— 1·4	— 1·5	+ 0·05	+ 0·08
O. Struve,	1850·39	355·2	2·74	— 2·8	— 2·9	— 2·9	— 0·16	— 0·14
Mädler,	1850·42	359·1	——	+ 1·1	+ 1·0	+ 1·0	——	——
Main,	1850·48	359·7	2·94	+ 1·8	+ 1·7	+ 1·7	+ 0·03	+ 0·05
Philpot,	1851·17	356·8	2·92	— 0·1	— 0·3	— 0·3	— 0·07	— 0·05
Mädler,	1851·28	357·9	2·99	+ 1·0	+ 0·9	+ 1·0	+ 0·01	+ 0·01
Main,	1851·36	356·3	3·04	— 0·5	— 0·6	— 0·5	+ 0·03	+ 0·05
Fletcher,	1851·40	356·0	3·05	— 0·7	— 0·8	— 0·8	+ 0·04	+ 0·06
Dawes,	1851·40	356·5	2·99	— 0·2	— 0·3	— 0·3	— 0·02	0·00
O. Struve,	1851·42	352·9	2·88	— 3·8	— 3·9	— 3·9	— 0·13	— 0·11
Miller,	1851·47	355·9	3·04	— 0·7	— 0·8	— 0·8	+ 0·02	+ 0·04
Mädler,	1851·98	356·6	3·30	+ 0·7	+ 0·5	+ 0·6	+ 0·22	+ 0·24
Jacob,	1852·24	355·4	3·12	— 0·2	— 0·3	— 0·3	+ 0·01	+ 0·03
Miller,	1852·26	355·5	3·12	— 0·1	— 0·1	— 0·1	+ 0·01	+ 0·03
Dawes,	1852·32	355·2	3·01	— 0·3	— 0·5	— 0·4	— 0·11	— 0·09
Fletcher,	1852·42	355·4	3·14	0·0	— 0·2	— 0·1	+ 0·02	+ 0·04
Smyth,	1852·42	355·5	3·2	+ 0·1	— 0·1	0·0	+ 0·08	+ 0·10
Mädler,	1852·43	354·6	3·17	— 0·8	— 1·0	— 0·8	+ 0·04	+ 0·07
O. Struve,	1852·43	353·1	3·00	— 2·3	— 2·5	— 2·3	— 0·13	— 0·10
Main,	1852·47	359·7	3·20	+ 4·4	+ 4·2	+ 4·3	+ 0·07	+ 0·09
Jacob,	1853·24	353·2	3·12	— 1·2	— 1·4	— 1·2	— 0·10	— 0·08
Powell,	1853·24	354·7	——	+ 0·3	+ 0·1	+ 0·3	——	——
Miller,	1853·27	354·9	3·10	+ 0·5	+ 0·3	+ 0·5	— 0·12	— 0·10
Fletcher,	1853·32	354·6	3·18	+ 0·3	+ 0·1	+ 0·3	— 0·05	— 0·03
Smyth,	1853·35	353·9	3·2	— 0·4	— 0·6	— 0·4	— 0·03	— 0·01
Dawes,	1853·36	354·1	3·06	— 0·2	— 0·4	— 0·2	— 0·17	— 0·15
Main,	1853·38	357·4	3·30	+ 3·1	+ 2·9	+ 3·1	+ 0·07	+ 0·09
Mädler,	1853·39	354·2	3·25	— 0·1	— 0·3	— 0·1	+ 0·02	+ 0·04
O. Struve,	1853·40	352·0	3·13	— 2·3	— 2·5	— 2·3	— 0·10	— 0·08
Jacob,	1853·91	353·0	3·06	— 0·7	— 0·9	— 0·7	— 0·23	— 0·21
Mädler,	1854·39	352·0	3·45	— 1·2	— 1·4	— 1·2	+ 0·11	+ 0·13
Dawes,	1854·39	352·7	3·21	— 0·5	— 0·7	— 0·5	— 0·13	— 0·11
Morton,	1854·40	352·1	3·40	— 1·1	— 1·3	— 1·1	+ 0·06	+ 0·08
Dembowski,	1854·46	353·6	3·26	+ 0·5	+ 0·3	+ 0·5	— 0·09	— 0·07
O. Struve,	1855·18	351·6	3·36	— 0·8	— 1·0	— 0·8	— 0·06	— 0·05
Dembowski,	1855·19	351·2	3·55	— 1·2	— 1·4	— 1·2	+ 0·13	+ 0·14
Philpot,	1855·30	353·4	——	+ 1·1	+ 0·9	+ 1·1	——	——
Main,	1855·39	353·5	3·45	+ 1·3	+ 1·1	+ 1·3	+ 0·01	+ 0·02
Secchi,	1855·40	352·6	3·37	+ 0·4	+ 0·2	+ 0·4	— 0·07	— 0·06
Smyth,	1855·40	351·6	3·4	— 0·6	— 0·8	— 0·6	— 0·04	— 0·03
Mädler,	1855·45	354·1	3·42	+ 2·0	+ 1·8	+ 2·0	— 0·03	— 0·02
Dawes,	1855·46	351·2	3·31	— 0·9	— 1·1	— 0·9	— 0·14	— 0·13
Morton,	1855·53	353·3	3·51	+ 1·2	+ 1·0	+ 1·2	+ 0·06	+ 0·07
Jacob,	1856·10	350·5	3·45	— 1·0	— 1·2	— 1·0	— 0·06	— 0·05
Dembowski,	1856·25	350·6	3·58	— 0·8	— 1·0	— 0·8	+ 0·06	+ 0·07
Main,	1856·29	349·0	3·54	— 2·3	— 2·5	— 2·3	+ 0·01	+ 0·02
Secchi,	1856·38	351·6	3·54	+ 0·4	+ 0·2	+ 0·4	0·00	+ 0·01
Mädler,	1856·39	351·7	3·59	+ 0·5	+ 0·3	+ 0·5	+ 0·05	+ 0·06

Observer	Epoch	θ_0	ρ_0	$\theta_0 - \theta_\rho$	$\theta_0 - \theta_1$	$\theta_0 - \theta_2$	$\rho_0 - \rho_1$	$\rho_0 - \rho_2$
Carpenter,	1856·96	353°·0	3″·64	+ 2°·3	+2°·2	+2°·4	+0″·04	+0″·05
Morton,	1856·97	351·3	3·66	+ 0·6	+ 0·5	+ 0·7	+ 0·06	+ 0·07
Schmidt,	1857·07	—	4·50	—	—	—	+ 0·89	+ 0·90
Dembowski,	1857·09	349·5	3·79	— 1·1	— 1·2	— 1·0	+ 0·18	+ 0·19
Dawes,	1857·35	350·1	3·59	— 0·3	— 0·4	— 0·2	— 0·04	— 0·03
Secchi,	1857·39	350·8	3·74	+ 0·5	+ 0·4	+ 0·6	+ 0·10	+ 0·11
Baxendell,	1857·40	352·9	3·58	+ 2·6	+ 2·5	+ 2·7	— 0·06	— 0·05
Smyth,	1857·41	350·6	3·5	+ 0·3	+ 0·2	+ 0·4	— 0·14	— 0·13
Fletcher,	1857·41	351·6	3·54	+ 1·3	+ 1·2	+ 1·4	— 0·10	— 0·09
Mädler,	1857·42	350·2	3·59	— 0·1	— 0·2	0·0	— 0·05	— 0·04
Dawes,	1857·42	349·9	3·56	— 0·4	— 0·5	— 0·3	— 0·08	— 0·07
O. Struve,	1857·44	350·2	3·63	— 0·1	— 0·2	0·0	— 0·10	0·00
Jacob,	1857·96	350·6	3·50	+ 0·8	+ 0·7	+ 0·9	— 0·19	— 0·18
Dembowski,	1858·34	348·5	3·79	— 1·0	— 1·1	— 0·9	+ 0·07	+ 0·08
Mädler,	1858·37	349·9	4·01	+ 0·5	+ 0·4	+ 0·6	+ 0·28	+ 0·30
Fletcher,	1858·39	350·0	3·57	+ 0·6	+ 0·5	+ 0·7	— 0·16	— 0·15
Smyth,	1858·39	349·9	3·8	+ 0·5	+ 0·4	+ 0·6	+ 0·07	+ 0·08
Secchi,	1858·40	352·0	3·61	+ 2·6	+ 2·5	+ 2·7	— 0·12	— 0·11
O. Struve,	1858·44	349·3	3·67	— 0·1	— 0·2	0·0	— 0·06	— 0·05
Dawes,	1858·45	348·8	3·68	— 0·6	— 0·7	— 0·5	— 0·05	— 0·04
Carpenter,	1858·47	348·0	3·85	— 1·4	— 1·5	— 1·3	+ 0·12	+ 0·13
Morton,	1858·48	350·7	3·40	+ 1·3	+ 1·2	+ 1·4	— 0·33	— 0·32
Morton,	1859·15	350·7	3·95	+ 1·9	+ 1·8	+ 2·0	+ 0·16	+ 0·17
Mädler,	1859·37	349·2	3·88	+ 0·6	+ 0·5	+ 0·7	+ 0·07	+ 0·08
O. Struve,	1859·38	347·9	3·76	— 0·7	— 0·8	— 0·6	— 0·05	— 0·05
Wakelin,	1859·39	350·0	4·18	+ 1·4	+ 1·3	+ 1·5	+ 0·37	+ 0·37
Secchi,	1859·44	349·5	3·91	+ 1·0	+ 0·9	+ 1·1	+ 0·09	+ 0·10
Dawes,	1859·46	348·2	3·77	— 0·3	— 0·4	— 0·2	— 0·05	— 0·04
Jacob,	1860·30	358·0	2·9	+10·1	0·0	+ 0·2	— 1·00	— 0·99
Mädler,	1860·35	345·9	3·90	— 1·9	— 2·1	— 1·9	0·00	+ 0·01
Knott,	1860·44	349·3	4·05	+ 1·5	+ 1·4	+ 1·6	+ 0·14	+ 0·15
O. Struve,	1861·15	346·9	3·93	— 0·4	— 0·5	— 0·3	— 0·04	— 0·03
Jacob,	1861·19	357·7	3·12	+10·4	+10·3	+10·5	— 0·85	— 0·85
Main,	1861·28	347·8	3·99	+ 0·6	+ 0·5	+ 0·7	+ 0·01	+ 0·02
Powell,	1861·31	346·1	3·94	— 1·1	— 1·2	— 1·0	— 0·04	— 0·03
Auwers,	1861·36	348·5	4·12	+ 1·4	+ 1·3	+ 1·5	+ 0·13	+ 0·14
Mädler,	1861·41	347·8	4·11	+ 0·7	+ 0·6	+ 0·8	+ 0·12	+ 0·13
Dawes,	1862·03	346·5	3·95	— 0·2	— 0·3	— 0·1	— 0·09	— 0·08
Powell,	1862·32	345·3	3·90	— 1·2	— 1·3	— 1·1	— 0·17	— 0·16
Mädler,	1862·38	345·5	4·39	— 0·9	— 1·0	— 0·8	+ 0·32	+ 0·33
Main,	1862·38	346·6	4·00	+ 0·2	+ 0·1	+ 0·3	— 0·07	— 0·06
O. Struve,	1862·41	346·0	3·97	— 0·4	— 0·5	— 0·3	— 0·10	— 0·09
Main,	1863·25	346·7	4·06	+ 0·9	+ 0·8	+ 1·0	— 0·08	— 0·07
Romberg,	1863·27	345·1	4·34	— 0·7	— 0·8	— 0·6	+ 0·20	+ 0·21
Dembowski,	1863·33	345·9	4·08	+ 0·1	0·0	+ 0·2	— 0·07	— 0·06
O. Struve,	1863·46	347·3	3·90	+ 1·6	+ 1·5	+ 1·7	— 0·26	— 0·25
Dembowski,	1864·28	344·9	4·09	— 0·2	— 0·3	— 0·1	— 0·13	— 0·12
Main,	1864·40	345·7	4·27	+ 0·7	+ 0·6	+ 0·8	+ 0·04	+ 0·05
Secchi,	1864·41	345·5	4·28	+ 0·5	+ 0·4	+ 0·6	+ 0·05	+ 0·06
O. Struve,	1864·42	345·0	4·06	0·0	— 0·1	+ 0·1	— 0·17	— 0·16
Dawes,	1864·44	345·4	4·10	+ 0·4	+ 0·3	+ 0·5	— 0·13	— 0·12
Knott,	1864·44	345·4	4·27	+ 0·4	+ 0·3	+ 0·5	+ 0·04	+ 0·05
Engelmann,	1865·14	346·3	4·01	+ 1·8	+ 1·7	+ 1·9	— 0·28	— 0·27
Dembowski,	1865·26	344·5	4·18	+ 0·1	0·0	+ 0·2	— 0·12	— 0·11
Main,	1865·36	345·2	4·28	+ 0·8	+ 0·7	+ 0·9	— 0·03	— 0·02
Dawes,	1865·42	344·0	4·37	— 0·4	— 0·5	— 0·3	+ 0·06	+ 0·07
Knott,	1865·45	344·3	4·34	0·0	— 0·1	+ 0·1	+ 0·03	+ 0·03
Secchi,	1866·31	344·3	4·39	+ 0·6	+ 0·4	+ 0·6	+ 0·02	+ 0·02
O. Struve,	1866·42	344·0	4·29	+ 0·3	+ 0·1	+ 0·3	— 0·09	— 0·09
Main,	1866·45	345·2	4·35	+ 1·6	+ 1·4	+ 1·6	— 0·03	— 0·03
Kaiser,	1866·46	345·9	4·01	+ 2·3	+ 2·1	+ 2·3	— 0·37	— 0·37
Talmage,	1866·48	343·4	4·53	— 0·2	— 0·4	— 0·2	+ 0·15	+ 0·15

Observer	Epoch	θ_0	ρ_0	$\theta_0 - \theta_p$	$\theta_0 - \theta_1$	$\theta_0 - \theta_2$	$\rho_0 - \rho_1$	$\rho_0 - \rho_2$
Dembowski,	1867·05	343°·6	4″·23	+0°·3	+0°·1	+0°·3	—0″·19	—0″·19
Talmage,	1867·24	342·9	5·28	— 0·3	— 0·5	— 0·3	+ 0·84	+ 0·84
Main,	1867·38	341·4	4·40	— 1·7	— 1·9	— 1·7	— 0·05	— 0·05
Talmage,	1868·26	340·6	5·06	— 2·0	— 2·1	— 1·9	+ 0·55	+ 0·55
Dembowski,	1868·28	343·4	4·31	+ 0·9	+ 0·7	+ 0·9	— 0·20	— 0·20
Main,	1868·42	341·0	4·63	— 1·5	— 1·7	— 1·4	+ 0·12	+ 0·11
O. Struve,	1868·45	343·3	4·30	+ 0·9	+ 0·7	+ 0·9	— 0·22	— 0·22
Brünnow,	1869·22	344·9	4·77	+ 2·9	+ 2·7	+ 3·0	+ 0·21	+ 0·10
Talmage,	1869·25	339·6	5·34	— 2·4	— 2·5	— 2·3	+ 0·77	+ 0·77
Main,	1869·49	339·8	4·74	— 2·1	— 2·2	— 1·9	+ 0·16	+ 0·15
Dunér,	1869·98	341·8	4·43	+ 0·2	+ 0·1	+ 0·4	— 0·18	— 0·19
Dembowski,	1870·25	342·6	4·61	+ 1·1	+ 1·0	+ 1·4	— 0·01	— 0·02
Gledhill,	1870·33	342·6	4·65	+ 1·2	+ 1·1	+ 1·4	+ 0·02	+ 0·01
Main,	1870·38	340·6	4·76	— 0·8	— 0·9	— 0·6	+ 0·13	+ 0·12
Talmage,	1870·39	338·6	——	— 2·8	— 2·9	— 2·6	——	——
O. Struve,	1870·77	343·3	4·44	+ 2·2	+ 2·1	+ 2·4	— 0·22	— 0·23
Dembowski,	1871·26	341·7	4·64	+ 0·8	+ 0·7	— 1·0	— 0·04	— 0·05
Main,	1871·35	340·9	4·54	+ 0·1	0·0	+ 0·3	— 0·15	— 0·16
Talmage,	1871·38	343·1	4·76	+ 2·3	+ 2·2	+ 2·5	+ 0·07	+ 0·06
Knott,	1871·38	339·8	4·49	— 1·0	— 1·1	— 0·8	— 0·20	— 0·21
Wilson,	1871·38	339·7	5·35	— 1·1	— 1·2	— 0·9	+ 0·66	+ 0·65
Gledhill,	1871·53	341·8	4·77	+ 1·1	+ 1·0	+ 1·3	+ 0·07	+ 0·06
Dunér,	1872·12	341·1	4·59	+ 0·7	+ 0·6	+ 0·9	— 0·15	— 0·16
Gledhill,	1872·30	339·7	4·4	— 0·7	— 0·7	— 0·4	— 0·35	— 0·36
Wilson,	1872·34	342·2	5·59	+ 1·9	+ 1·8	+ 2·1	+ 0·84	+ 0·83
Dembowski,	1872·37	341·3	4·54	+ 1·0	+ 0·9	+ 1·2	— 0·21	— 0·22
Talmage,	1872·37	338·6	4·80	— 1·7	— 1·8	— 1·5	+ 0·05	+ 0·04
Knott,	1872·40	341·5	4·82	+ 1·2	+ 1·1	+ 1·4	+ 0·07	+ 0·06
O. Struve,	1872·41	340·0	4·64	— 0·3	— 0·4	— 0·1	— 0·11	— 0·12
Main,	1872·41	340·3	4·78	0·0	— 0·1	+ 0·2	+ 0·03	+ 0·02
Wilson,	1873·23	341·9	4·9	+ 2·0	+ 1·9	+ 2·2	+ 0·10	+ 0·09
Dembowski,	1873·34	340·2	4·64	+ 0·4	+ 0·3	+ 0·6	— 0·17	— 0·18
Main,	1873·40	340·2	4·83	+ 0·4	+ 0·3	+ 0·6	+ 0·02	+ 0·01
Gledhill,	1873·41	339·7	4·65	— 0·1	— 0·2	— 0·1	— 0·16	— 0·17
O. Struve,	1873·43	340·8	4·54	+ 1·0	+ 0·9	+ 1·2	— 0·28	— 0·28
Lindstedt,	1873·46	340·5	4·96	+ 0·8	+ 0·6	+ 0·9	+ 0·14	+ 0·13
Gledhill,	1874·27	340·5	5·08	+ 1·2	+ 1·0	+ 1·3	+ 0·21	+ 0·21
Wilson,	1874·31	341·1	5·01	+ 1·9	+ 1·7	+ 2·0	+ 0·14	+ 0·13
Talmage,	1874·32	339·3	5·39	+ 0·1	— 0·1	+ 0·2	+ 0·52	+ 0·51
Main,	1874·33	338·5	5·23	— 0·7	— 0·9	— 0·6	+ 0·36	+ 0·35
Dembowski,	1874·35	339·9	4·65	+ 0·7	+ 0·5	+ 0·8	— 0·22	— 0·23
O. Struve,	1874·41	340·4	4·87	+ 1·2	+ 1·0	+ 1·3	0·00	— 0·01
Dunér,	1875·14	339·1	4·66	+ 0·3	+ 0·1	+ 0·4	— 0·26	— 0·27
Gledhill,	1875·22	338·5	4·86	— 0·3	— 0·5	— 0·2	— 0·06	— 0·07
Dembowski,	1875·28	338·9	4·84	+ 0·2	— 0·1	+ 0·2	— 0·09	— 0·10
Main,	1875·29	339·8	5·09	+ 1·1	+ 0·8	+ 1·1	+ 0·16	+ 0·15
Wilson,	1875·30	340·5	4·97	+ 1·8	+ 1·5	+ 1·8	+ 0·04	+ 0·03
Schiaparelli,	1875·37	339·6	4·91	+ 0·9	+ 0·7	+ 1·0	— 0·02	— 0·03
Doberck,	1876·24	338·7	5·34	+ 0·5	+ 0·2	+ 0·5	+ 0·36	+ 0·35
Gledhill,	1876·27	338·5	4·78	+ 0·3	0·0	+ 0·3	— 0·21	— 0·22
Dembowski,	1876·35	338·7	4·87	+ 0·6	+ 0·3	+ 0·5	— 0·12	— 0·13
Talmage,	1876·36	340·0	——	+ 1·9	+ 1·6	+ 1·8	——	——
Stone,	1876·38	339·8	5·30	+ 1·7	+ 1·4	+ 1·7	+ 0·31	+ 0·30
Waldo,	1876·40	339·7	4·64	+ 1·6	+ 1·3	+ 1·6	— 0·35	— 0·36
Hall,	1876·41	340·2	5·15	+ 2·1	+ 1·8	+ 2·1	+ 0·16	+ 0·15
Schiaparelli,	1876·45	339·0	4·84	+ 0·9	+ 0·6	+ 0·9	— 0·16	— 0·17
Main,	1876·48	338·2	5·18	+ 0·1	— 0·2	+ 0·1	+ 0·18	+ 0·17
Gledhill,	1877·07	338·5	——	+ 0·8	+ 0·4	+ 0·7	——	——
Plummer,	1877·24	340·0	4·65	+ 2·3	+ 2·0	+ 2·2	— 0·39	— 0·40
Doberck,	1877·28	335·8	5·04	— 1·9	— 2·2	— 2·0	0·00	— 0·01
Knott,	1877·29	338·5	4·84	+ 0·8	+ 0·5	+ 0·7	— 0·20	— 0·21
Stone,	1877·30	338·1	5·19	+ 0·4	+ 0·2	+ 0·4	+ 0·15	+ 0·14

Observer	Epoch	θ_o	ρ_o	$\theta_o - \theta_p$	$\theta_o - \theta_1$	$\theta_o - \theta_2$	$\rho_o - \rho_1$	$\rho_o - \rho_2$
Dembowski, .	1877·31	338°·1	4″·89	+0°·5	+0°·2	+0°·4	—0″·16	—0″·17
Jedrzejewcz, .	1877·40	339·5	4·91	+ 1·9	+ 1·6	+ 1·8	— 0·14	— 0·15
Flammarion, .	1877·43	338·4	4·96	+ 0·7	+ 0·5	+ 0·7	— 0·09	— 0·10
Goldney, .	1878·37	337·1	5·06	0·0	— 0·3	— 0·1	— 0·04	— 0·05
Gledhill, .	1879·35	338·6	5·00	+ 2·0	+ 1·5	+ 1·8	— 0·15	— 0·16
Hall, .	1879·37	338·3	5·20	+ 1·7	+ 1·3	+ 1·6	+ 0·05	+ 0·04
Hall, .	1880·30	338·2	5·27	+ 2·2	+ 1·5	+ 1·8	+ 0·09	+ 0·08
Gledhill, .	1880·31	337·3	4·90	+ 1·3	+ 0·6	+ 0·9	— 0·28	— 0·30
Doberck, .	1880·37	338·1	4·95	+ 2·1	+ 1·5	+ 1·7	— 0·23	— 0·25
Gledhill, .	1881·24	336·3	5·40	+ 0·7	0·0	+ 0·3	+ 0·18	+ 0·17
Doberck, .	1881·24	337·1	5·02	+ 1·5	+ 0·8	+ 1·1	— 0·20	— 0·21

In conclusion I have thought it worth while to give a separate comparison of the observations made by O. Struve, both the uncorrected observations and the corrected ones, which have been used above. The observed distances are improved by the corrections, except before 1843 when no corrections ought to be applied, as appears not only from γ Virginis but from almost all the double-stars I have investigated. This is also confirmed by looking at the angles; but here the observations are better without the corrections as late as 1853. It must be remembered that the corrections were determined by experiments made after this year. They have been copied from "Observations de Poulkowa," Vol. IX.

OBSERVER :—O. STRUVE.

Epoch	θ_1	θ_0		ρ_1	ρ_0	
		corr.	obs.		corr.	obs.
1840·45	25°·5	31°·6	25°·4	1″·36	1″·42	1″·30
41·41	20·1	22·4	16·7	1·56	1·63	1·50
42·41	15·8	17·1	13·6	1·77	1·86	1·73
45·46	6·8	4·6	5·5	2·32	2·23	2·11
46·38	4·7	2·9	3·3	2·44	2·35	2·22
47·42	2·6	2·5	3·0	2·57	2·40	2·27
48·43	0·9	359·1	0·5	2·68	2·55	2·44
49·41	359·4	353·0	355·5	2·79	2·64	2·54
50·39	358·1	355·2	356·8	2·90	2·74	2·61
51·41	356·8	353·0	355·9	3·01	2·88	2·77
52·43	355·6	353·0	356·0	3·13	3·00	2·88
53·40	354·5	352·0	354·6	3·23	3·13	3·01
55·18	352·6	351·6	354·8	3·42	3·30	3·20
57·44	350·4	350·2	353·1	3·64	3·64	3·51
58·44	349·5	349·3	351·9	3·73	3·67	3·56
59·38	348·7	347·9	349·7	3·82	3·76	3·63
61·15	347·4	347·0	348·5	3·98	3·93	3·78
62·40	346·5	345·9	347·6	4·07	3·97	3·83
63·46	345·8	347·4	349·7	4·16	3·90	3·80
64·42	345·1	345·1	347·1	4·23	4·06	3·96
66·42	343·9	344·0	345·7	4·38	4·29	4·19
68·44	342·6	343·2	345·3	4·51	4·30	4·27
70·77	341·2	343·4	344·8	4·66	4·45	4·37
72·41	340·4	340·0	342·3	4·75	4·64	4·54
73·43	339·9	340·9	342·7	4·81	4·55	4·48
74·41	339·4	340·4	341·7	4·87	4·87	4·78

Markree Observatory, June 1881.

SUPPLÉMENT AUX TABLES ÉCLIPTIQUES DE P. A. HANSEN.

PAR H. C. F. C. SCHJELLERUP.

	g	(*a*)	33	(*a*)	34	36	(*a*)	39	(*a*)	41	(*a*)
− 2200	11·0333	− 790	8·7305	− 208	49·99	12·24	+ 15	7·85	− 9	13·76	− 7
2100	26·1747	771	4·3728	203	49·04	142·28	15	24·30	8	2·16	7
2000	13·7635	753	0·0155	198	48·10	99·02	14	10·96	8	16·17	7
1900	1·3541	734	25·1893	193	47·16	55·74	14	27·41	8	4·56	7
1800	16·5012	715	20·8330	188	46·21	12·48	14	14·07	8	18·58	7
1700	4·0955	697	16·4772	184	45·27	142·50	13	0·73	8	6·98	6
1600	19·2463	678	12·1219	179	44·32	99·22	13	17·20	7	21·00	6
1500	6·8444	659	7·7671	174	43·38	55·93	12	3·86	7	9·41	6
1400	21·9990	640	3·4128	169	42·43	12·65	12	20·33	7	23·43	6
1300	9·6009	621	28·5896	164	41·49	142·66	12	7·00	7	11·84	6
1200	24·7593	602	24·2363	159	40·54	99·36	11	23·47	7	0·24	6
1100	12·3650	583	19·8835	154	39·59	56·06	11	10·14	6	14·27	5
1000	27·5272	564	15·5311	149	38·64	12·76	10	26·62	6	2·68	5
900	15·1368	544	11·1793	144	37·70	142·76	10	13·29	6	16·72	5
− 800	2·7483	− 525	6·8280	− 138	36·75	99·45	+ 10	29·77	− 6	5·13	− 5

	28	ε	ω	(*a*)	Π	(*a*)
− 2200	584	23° 58′ 33″	335°·028	+ 927	303°·901	+ 754
2100	3121	57 48	219·144	905	53·697	737
2000	5657	57 2	103·239	883	163·475	719
1900	1396	56 16	347·312	861	273·236	701
1800	3932	55 30	231·362	839	22·978	683
1700	6469	54 45	115·391	817	132·703	665
1600	2207	53 59	359·398	795	242·410	647
1500	4743	53 13	248·382	773	352·099	629
1400	481	52 27	127·345	751	101·770	611
1300	3017	51 41	11·285	728	211·423	593
1200	5553	50 55	255·202	706	321·057	575
1100	1291	50 9	139·098	683	70·674	557
1000	3826	49 23	22·970	661	180·272	538
900	6362	48 37	266·821	638	299·851	520
− 800	2099	47 51	150·648	+ 616	39·413	+ 501

Les tables écliptiques, servant au calcul approximatif des eclipses, sont publiées dans les "Berichte der k. Sächsischen Gesellschaft der Wissenschaften," IX. (1857), pp. 75–112.

NOTE ON THE NEBULA NEAR MEROPE.

By J. L. E. DREYER.

In the number for June 1881 of the "Monthly Notices" Messrs. Hough and Burnham have published a note on the nebula at *Merope*. The Authors examined the object with various powers on the Chicago Refractor and failed to see it, or saw it only when the bright star was in the field. Having been led to the conclusion that the nebula does not exist, the Authors compare the statements of different observers, and come to the result that they are so discordant as to shape and position, that very little reliance can be placed on them, and that the various appearances are due to the glow proceeding from *Merope* and neighbouring stars.

Before making any remarks on the way in which the notes and drawings made by other observers may be interpreted, I shall quote my own observations, made with Lord Rosse's 6-feet reflector, and which have escaped the attention of Messrs. Hough and Burnham (Observations of Nebulæ at Birr Castle 1848–78, p. 38).

"1877 Dec. 10. Large finder eye-piece (diam. 26′). I saw first that f a line through 2 stars sf the ground is blacker than p that line; when I pointed it out to Lord R. he saw it also, and could distinguish the p limit too, forming an angle of about 40° with the f limit. I saw it too, but less distinctly."

"1877 Dec. 27. Large finder eye-piece. Was struck with it at first sight when the star had been placed in the middle of the field. The angle at the star is about 50°. Rough sketch of field with principal stars. Very few more seen with higher power. I think the brilliancy of the bright star is the principal reason why it is not seen with a higher power."

I do not now remember the power of the eye-piece in question, but it was certainly not higher than 200, and consequently the pupil of the observer's eye did not receive light from the whole of the large speculum. In 1875 I had attempted to see the Merope nebula with the same telescope, using a power of about 400, but I did not succeed in seeing any nebulosity. The rough sketch made in 1877 and copied in the Birr Observations is in very good accordance with the drawing of M. Tempel (Publ. dell' Oss. di Brera No. 5 and Month Not. XL.) and I may remark that I was entirely free from any bias as I never saw M. Tempel's drawing until the autumn of 1878.

The drawing by Mr. Maxwell Hall (Monthly Notices Jan. 1880) agrees well with that of M. Tempel, and this is also stated to be the case with a drawing made by Mr. Pratt (*ibid.* Mar. 1881). Differing from these observers are Prof. Schiaparelli and M. Wolf, who make the nebulosity extend towards *Electra* and *Celeno* (north preceding), while Mr. Common (Month. Not. Apr. 1880) sees a long streak sf *Merope*, but quite detached from it, and a small roundish nebula nf *Merope*, also detached. The latter it appears that Mr. Pratt has also seen. Professor Holden (whose observations are quoted by Messrs. Hough and Burnham) has on one occasion seen the great mass of nebulosity on the south side and smaller masses north and following, separated from the star by dark spaces; on another occasion he saw a narrow wisp a little following *Merope* and extended in Position 150°±.

The tiny speck on Dr. Engelmann's map of the Plejades it is better not to take into account, as he has not mentioned it anywhere himself, while he states expressly (Bessel's Abhandlungen Bd. II, Preface) that the sky was not very clear and the *Merope* nebula not visible on the night when the map was made.

The above accounts do not appear to be quite as irreconcilable as supposed by Messrs. Hough and Burnham. It seems to me, that all the evidence as to nebulosity near *Merope* may be put together as follows :—

1. According to Tempel, Lord Rosse and Dreyer, Maxwell Hall, Pratt and Holden (one night) there is a large parabolic or comet-like nebulosity extending from *Merope* south preceding, Position of axis about 210°.

2. According to Wolf and Schiaparelli the nebula extends north preceding towards *Electra* and *Celeno*, Pos. 310°±.

3. According to Common there is a streak sf Pos. 135°, (apparantly seen once by Holden) and a small patch in Pos. 45° (seen by Pratt).

The evidence under (2) is not necessarily opposed to that under (1), as most observers under (1) let the nebula extend more or less towards *Electra,* and I have myself seen many cases of a large and diffused nebulosity on different nights appearing to extend more or less in different directions. That what the observers under (1) and (2) have seen, should be nothing but an illusion, is not likely to be conceded by any of them, and it seems difficult to imagine how the glare of the bright star could produce an appearance of nebulosity at one side only. There are many cases, in which an observer has believed a bright star to be nebulous, while all subsequent observers have failed to see any nebulosity, but in all such cases the star has by the first observer been described as being *surrounded* by an atmosphere. About these appearances round bright stars see Sir John Herchel's remarks, Phil. Trans. 1833 pp. 499–500.

As any statement made by two experienced observers like Messrs. Hough and Burnham cannot fail to carry a certain weight with it, and as they quoted my remark in *The Observatory* Vol. I p. 370 about the visibility of the object in question, the above description of what I have seen may not be entirely uncalled for.

THE POLARIZATION OF LIGHT FROM COMET *b* 1881.

BY ARTHUR W. WRIGHT.

(From the American Journal of Science for August 1881. Communicated in advance by the Author.)

Polariscopic observations of the comet were made on the evenings of June 25 and 26, which gave faint indications of the existence of polarization, but with the instruments then used it was not possible to ascertain satisfactorily either its character or amount. The state of the sky was not very favourable for observation until the evening of June 29, when a method of observation was found which made it possible to determine the polarization, which was at once seen to be considerable, with comparative ease and a good degree of precision.

The instrument employed was the polarimeter constructed for observation of the solar corona in the eclipse of July 29, 1878, and described in the volume containing the reports upon this eclipse issued from the U. S. Naval Observatory.* A slight modification was made by substituting a Savart plate for the selenite, it being attached to the Nichol's prism in the eye-piece. This gave a rather narrow field which was nearly filled by the image of the comet, an arrangement very favourable for detection of the bands caused by polarization. The aperture of the telescope to which the polarimeter is attached is three inches.

The plane of polarization of the light was found to have such a direction as to pass through the sun's place. This was determined both by the disposition of the bands seen in the polarimeter, and also independently by means of a double-image prism placed before the ordinary eye-piece of the telescope when this was attached to the instrument. The two images of the comet as the prism was rotated were easily seen to have different intensities in certain positions corresponding to polarization in a plane situated as above described. As seen with this instrument the fainter of the images appeared considerably shorter than the other as if the light coming from towards the extremity of the tail were more strongly polarized than that from points near the nucleus. But this was possibly an illusion depending upon the fact that when the very faint light was diminished by the polarizing effect it became too feeble for perception, and this lessened the extent of the visible area. When examined with the polarimeter the light appeared to be slightly less strongly polarized as the instrument was directed to points more remote from the head of the comet, as would be the case if the proportion depended simply upon the angle of incidence of the light, which decreased with the distance from the nucleus. The second and third of the observations of July 1, in the list below, were made upon regions removed several degrees from the nucleus, but though the amount of polarization is somewhat less, and tends to confirm the above conclusion, the difference is hardly greater than would be accounted for by the errors of observation. Determinations of polarization at great distances from the nucleus were not possible, the light being too feeble.

In the use of the polarimeter, the latter was fitted so that a card could be attached to the slide moving the glass plates. The positions were pricked upon this with a needle point, and were read off by means of the graduated circle after the observations were finished. The latter were made in sets of ten, the plates being moved to the point of neutralization, or disappearance of the bands, first from below, then from above, alternately, until five had been made from each direction. The points upon the card thus fell into two groups separated by an interval which was greater or less according to the degree of polarization. The mean of the angles for each set of five being taken, the per-centage of polarized light corresponding to each was determined from a curve constructed for the instrument. Two values were thus obtained the mean of which was the amount of polarization for the point observed. Each card was capable of containing two sets of points, and could be removed or replaced by another without the aid of a light, a necessary precaution in observations of such delicacy, as the proper sensitiveness of the eye could only be maintained by seclusion from the light.

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* Reports on the Total Solar Eclipses of July 29, 1878, and January 11, 1880, pp. 264–267.

The results of the observations are given in the following table. The date and local mean time for the series of each evening are given in column I. In column II are given the results derived from the sets of determinations arranged in their order as made, each result, as explained above, being obtained by ten measurements. The numbers express the proportion of polarized light to the total light reckoned as one hundred parts. The means of the per-centages of the sets in column II for each evening are given in column III. Column IV gives the approximate angles of incidence of the light derived from the sun, referred to the nucleus or points very near it. It is obtained from the ephemeris of Peters,* combined with that of Oppenheim given in the Dun Echt Circular No. 24. The angles subtended at the comet by the earth's radius vector at the dates of the ephemeris were obtained by a simple graphic process. With these a curve was constructed from which the angles for the dates of the different observations were derived. These divided by two are the angles of incidence.

I.	II.	III.	IV.
June 29, 1^h to 2^h, A.M.	24·7 23·8 21·3	23·3	60°·5
June 30, 1^h to 2^h, A.M.	18·1 17·6 18·6 17·1	17·8	58°
July 1, 11^h to 12^h 30^m P.M.	21·8 20·1 17·6 17·7	19·3	54°·5
July 2, 10^h 30^m to 11^h P.M.	16·9 16·9	16·9	52°·5
July 3, 10^h 30^m to 12^h P.M.	18·3 18·0 18·7	18·3	51°
July 21, 11^h 30^m P.M. to 1^h.	15·9 15·6	15·7	33°
July 22, 11^h 30^m P.M. to 1^h.	14·5 13·8	14·1	32°

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* Astronomische Nachrichten, No. 2381, p. 75.

The observation of July 2 was made under rather unfavourable atmospheric conditions, and the sky was somewhat luminous from auroral action. The amount of polarization found is undoubtedly less than the true value. The others were made when the sky was very clear, and during those of July 21 and 22 it was exceptionally fine. The time of the observations precluded the possibility of any influence from twilight or the light of the moon.

On comparing the per-centage of light polarized and the angles of incidence it is seen that they decrease together. No definite maximum was made out, but the existence of one near or beyond 60° is perhaps indicated by the fact that polarization was less easily observed on the evenings previous to June 29, and by the more rapid variation in the per-centages on this and the two succeeding evenings. At first sight the large per-centages obtained in the earlier observations appeared to indicate reflection from a gaseous substance, but the numbers found later, and especially the relation of all the values to the angles of incidence, render an inference as to the character of the reflecting material more difficult. It is not improbable that the constitution and physical condition of the matter composing the tail were variable, and this circumstance would introduce changes in the proportion of polarized light, in addition to those produced by the alteration in the angle of the reflected rays. The fact of polarization shows that a large part, probably the greater part, of the light coming from the tail is reflected sunlight.

Yale College, July 25, 1881.

PHOTOGRAPH OF THE NEBULA IN ORION.

Professor Henry Draper has sent over to this country enlarged copies of the Photograph of the Nebula in Orion which he took on March 11th 1881 with an exposure of 104 minutes, as stated in a note appended to the photograph. The instrument used was a refractor with a triple objective of 11 inches aperture, corrected for chemical rays. On other occasions the exposure was 140 minutes. The most sensitive of Eastman's Gelatine Plates were used.

The copy before us is about $5\frac{1}{8}$ by $6\frac{5}{8}$ inches and shows the central part of the nebula on a scale of $160''$ to an inch. As may readily be imagined the large stars are much over-exposed, *e.g.*, the trapezium is shown as an oval patch about $\frac{1}{3}$ inch long, while even the 5th magnitude star *h* 93 is 0·3 inch in diameter. In all, at least 17 stars or groups of stars are shown; the smallest that we can certainly make out being *h* 84 ($160''$ *n* and $60''$ *f* the brightest star of the trapezium) which is represented as a round nebula 0·06 inch in diameter. Its magnitude as given by Liapounov is 12 of Struve's scale.

This result is sufficiently surprising, but it is the nebula itself as reproduced in the photograph which claims our enthusiastic admiration. The whole of the Huyghenian Region is shown with wonderful clearness except immediately in the neighbourhood of bright stars. Using the Herschel-D'Arrest nomenclature, the *Sinus Gentilii, Sinus Lamontii* and the whole region surrounding the *Sinus magnus* with the *Pons Schroeteri* may be mentioned as being represented with great distinctness. The two remarkable small, dark gulfs shown in Lord Rosse's drawing to the north of the trapezium are also fairly indicated as well as the tails stretching out to the south-following from the *frons* and to the south from the three large stars 93, 101 and 110. The outline, too, of the very faint "lower jaw" can be readily traced. The chief subdivisions of the *frons* and *occiput* are represented perhaps in closer agreement with Bond's drawing than with any other, the Birr engraving giving more detail.

Towards the edges of the space contained in the photograph an absence both of nebula and faint stars seem to indicate that the whole of the plate has not been exposed to the action of rays from every part of the speculum.

Probably from refraction combined with a slight irregularity in the clock-rate all the stars are somewhat elongated in a *nf* direction.

The photograph has suffered little or no distortion in the enlargement as may be found by comparing the relative distances of the stars with Liapounov's map.

Doubtless a reference to the original negative would reveal more features than can be readily made out in the enlarged copy, but even this would prove an invaluable guide in an examination of the chief existing drawings of the Great Nebula. As an experiment it shows the immense capabilities of the method and we cannot too heartily congratulate Dr. Draper on his success.

COMET *b* 1881.

Dun Echt Circular, No. 24 (July 2) contains the following communication by Dr. H. Oppenheim:—

"Aus den Beobachtungen zu Kiel, 1881, Juni 22 und 24 und Leipzig, Juni 26 erhielt ich folgende Elemente des Cometen:—

$$\begin{array}{rl} T = & \text{1881, Juni 16·3429 M. Zt. Berlin.} \\ \pi - \Omega = & \left.\begin{array}{l} 353^\circ\ 55'\ 55'' \\ 270\ \ 58\ \ 29 \\ \ \ 63\ \ 31\ \ \ \ 7 \end{array}\right\}\text{Mitt. Aeq. 1881·0} \\ \Omega = & \\ i = & \\ \log q = & 9{\cdot}86500 \end{array}$$

Die Darstellung der mittleren Beobachtung ist:—

$d\lambda \cos\beta = +11''$ $\qquad d\beta = +2''$ "

The Ephemeris, founded on these elements and issued in the same circular, has since been reprinted in the "Astronomische Nachrichten." The path of the Comet during the last days of August may be seen from the following extract:—

1881. 12h M. T. Berlin.	α	δ
Aug. 20,	14h 32m·9	77° 12′
24,	14 47·5	76 40
28,	15 2·0	76 10
Sept. 1,	15 16·5	75 39

Two meridian observations of the Comet made at Madrid and also printed in Circular No. 24, have since together with several others been reprinted in the Astronomische Nachrichten, No. 2382.

Dr. H. Draper has succeeded in taking several good photographs of the Comet; one with an exposure of $2^h\ 42^m$ shows the tail about 10° long and many stars through it.

No. 213 of the "Proceedings of the Royal Society" contains a "Preliminary Note on the Photographic Spectrum of Comet *b* 1881" by Dr. Huggins. On June 24 the Author obtained a photograph of the spectrum with one hour's exposure and one half of the slit and afterwards photographed the spectrum of Arcturus on the same plate, using the other half of the slit (see above p. 81). The spectrum of the comet was after development found to consist of a pair of bright lines in the ultra-violet region with wave-lengths 3883 and 3870. The less refrangible line is much stronger, and a faint luminosity can be traced from it to a little beyond the second line at 3870. There can be no doubt that these lines represent the brightest end of the ultra-violet group which appears under certain circumstances in the spectra of the compounds of carbon. Professors Liveing and Dewar have found for these lines the wave-lengths 3882·7 and 3870·5. Dr. Huggins was also able to see upon the continuous spectrum (which could be traced from about F to some distance beyond H) a distinct impression of the group of lines between G and h, which is usually associated with the group described above. Dr. Huggins finds for the less refrangible end of this group a wave-length of 4230, which agrees as well as can be expected with Professors Liveing and Dewar's measure 4220. These authors (Proc. R.S. XXX., p. 494) show that these two groups indicate the presence of cyanogen and are not to be seen in the absence of nitrogen. If this be the case, the photograph gives undoubted evidence of the presence of nitrogen in the comet, in addition to the carbon and hydrogen shown to be there by the bright groups in the visible part of the spectrum. On this hypothesis we must further suppose a high temperature in the Comet unless the cyanogen is present ready formed. It may also be mentioned that Mr. Lockyer regards the two groups in the photograph, and the groups in the visible spectrum, to be due to the vapour of carbon at different heat-levels (Proc. R.S. XXX., p. 461).

MERIDIAN OBSERVATIONS OF COMET *b* 1881.

Made with the Pistor and Martins Meridian Circle at Dunsink, by J. L. E. **Dreyer.**

1881.	Dublin M. T.	App. α.	App. δ.
June 27,	11ʰ 28ᵐ 2ˢ	5ʰ 52ᵐ 55ˢ·47	+ 60° 16′ 31″·8
30,	11 36 4	6 12 48·81	68 11 27·5
July 1,	11 40 21	6 21 2·69	70 17 0·8
6,	12 17 13	7 17 47·71	77 37 56·3

The Declinations are not corrected for parallax. Although I lost no opportunity between June 23 and July 11, I only succeeded in getting the above observations, as there was not a single cloudless night during that period.

COMET *c* 1881.

Dun Echt Circular, No. 25 (July 20):

"A telegram to the following effect has been received from the Vienna Academy. Comet Schaeberle, July 18, 13ʰ 33ᵐ, Vienna M. T.—

$$\alpha = 5^h\,52^m\,36^s, \text{ daily motion } + 1^m\,52^s.$$
$$\delta = +\,40^\circ\,11' \quad ,, \quad +\,28'$$

Bright."

Dun Echt Circular, No. 26 (July 21):

The *Science Observer*, Boston, U. S., has transmitted the following elements and ephemeris of Comet *c* (Schaeberle), which have been computed by S. C. Chandler, Jr., from observations made at Harvard College and Ann-Arbor Observatory—

$$\begin{aligned} T &= 1881 \text{ August } 18{\cdot}63 \text{ Gr. M. T.} \\ \pi &= 221^\circ\,41' \\ \Omega &= 99 \quad 9 \\ i &= 141 \quad 54 \\ \log q &= 9{\cdot}79442 \end{aligned} \left.\begin{matrix} \\ \\ \\ \\ \end{matrix}\right\} \text{Mean Equinox 1881.}$$

Ephemeris for Washington Midnight.

1881	α			δ	
July 22	6ʰ	1ᵐ	12ˢ	+ 41°	50′
26	6	12	16	43	36
30	6	27	32	45	35
Aug. 3	6	49	52	47	50

The Comet will rapidly get much brighter. These particulars have been telegraphed in twenty-one words by the self-checking system devised by Messrs. S. C. Chandler, Jr., and J. Ritchie, Jr., for the transmission of astronomical data.

Dun Echt Circular, No. 27 (July 23):

From observations made on July 18, 19, 20, Mr. Lohse and I have computed the following elements and ephemeris, which have been transmitted to America to test the working of the *Science Observer* code—

$$T = 1881 \text{ August } 21{\cdot}49823 \text{ Gr. M. T.}$$

$$\left.\begin{array}{rl} \pi & = 218^\circ\ 44'\ 46'' \\ \text{☊} & = 97\ \ 35\ \ 37 \\ i & = 140\ \ 36\ \ 55 \end{array}\right\}\text{Mean Equinox 1881.}$$

$$\Delta\lambda \cos\beta = +\,25'',\ \Delta\beta = -\,12''$$

Ephemeris for Berlin Midnight.

1881	α	δ	log r	log Δ
Aug. 3	$6^h\ 43^m\ \ 5^s$	$+\,47^\circ\ 46'$	9·8729	0·0447
7	7 11 24	50 11	9·8496	9·9861
11	7 54 54	52 20	9·8299	9·9208
15	8 59 28	52 57	9·8155	9·8524

THE COMET OF 1733.

Dr. Gould's telegram and also the general resemblance of the elements of Comet *b* 1881 to those of the Great Comet of 1807 induced an early belief in the possible identity of these two bodies, with a period of 74 years. This opinion gained strength when it was found that a comet had been seen at the Cape of Good Hope in 1733, just 74 years previous to 1807. We are indebted to M. Tisserand for having drawn attention to this fact—see *Comptes Rendus,* T. XCII., p. 1478.

The only passages accessible to us in which the Comet of 1733 is mentioned are:—

1. Struyck, Vervolg van de Beschryving der Staartsterren, p. 61.

“*De Comeet van't Jaar* 1733.

“Behalven't gene ik voortyds gevonden had, dat in't Jaar 1733 den 17$^{\text{den}}$ *Mey,* omtrent de Kaap de Goede Hoop, by de Baai *Fals* een Comeet gezien was[*], heb ik uit het Kaapse Dagregister nog het volgende vernomen.

“A°. 1733, Maandag den 18$^{\text{den}}$ *Mey,* was 'er 's avonds door eenige menschen alhier, een groote Ster met een Staart gezien.

“Dingsdag den 19$^{\text{den}}$ *Mey,* werdt deeze Tafelbaai bestevend door't Schip *de Spiering,* 't welk den 31$^{\text{sten}}$ *January* 1733 uit het Vaderland in Zee geloopen was, hier van hadt het Volk voor hunne aankomst de Staartster ook gezien.

“Donderdag den 28$^{\text{sten}}$ *Mey,* daagde alhier op, 't Retourschip 't *Hof niet altyd Zomer.* De opperhoofden van dien bodem verhaalden, dat zy op't Rif van *Anguilhas* de gemelde Staartster ook gezien hadden.”

2. Pingré cométographie T. II., p. 44.

“1733. Le 17 Mai, par 34° 39' de latitude australe, près de False-bay, au voisinage du cap de Bonne-espérance, on vit une Comète au nord-ouest-quart-ouest; le ciel étoit beau, la queue tendoit en haut, on la jugeoit longue de deux pieds: on vit cette Comète durant plus d'une heure jusqu'a son coucher. On la découvrit le lendemain 18, au cap même. Plusieurs Navigateurs, qui y arrivèrent le 19 & le 28 Mai, s'accordèrent à rapporter qu'ils avoient vu cette Comète.”

“[*] Korte Beschryving van alle de Comeeten pag. 300 en 301, *Amst.* 1740.” We have not been able to consult this work.

At the suggestion of Admiral Mouchez, Dr. Oudemans has caused search for farther particulars to be made in the Dutch colonial archives at the Hague which resulted in finding an extract from the log of the ship *Ypenroode*, which states that being in sight of the land near the Cape in latitude 34° 59′ and 39° of longitude [East of Ferro], on May 17 at about eight o'clock in the evening a comet was seen in the N.W. $\frac{1}{4}$ W. which remained visible until it set (Comp. Rend. XCIII., p. 173.) This is evidently a more complete version of the observation given by Pingré.

From these data Dr. Oudemans finds that the comet was in right ascension $6^h\ 5^m$ and declination — 18° 33′ and concludes that it cannot be identical with either the comet of 1807 or Comet *b* 1881.

Some error must have crept into Dr. Oudemans' computation of the comet's place, for if it is assumed that the uncorrected compass-bearing was entered in the log-book, the place would be R.A. $7^h\ 30^m$ and 12° north declination, 16° W. being taken as the magnetic declination at the Cape in 1733—a conjecture which cannot be far from the truth. Or if we make the improbable assumption that the bearing was corrected for the magnetic declination the comet was in about $8^h\ 3^m$ and + 25°.

Neither of these places indicate any connexion with the orbits of the great comets of 1807 or 1881. A startling fact, however, forces itself on the attention. *The comet must have been plainly visible throughout Europe.*

Why was the comet not generally observed? The Cape accounts go far to prove that although the comet was a large one it was visible for a few days only. As far as the weather at Berlin is concerned we have very complete memoranda in the diary kept for more than half a century by various members of the Kirch family and now in the library at Dun Echt. From this it appears that the weather during May 1733 was generally unfavourable to astronomical observation. Although it was clear after sunset on the 13th, not another fine evening is mentioned until the 22nd when there was bright moonlight, the moon being nine days old. The moon was eclipsed on the 28th but the weather was quite thick. "N.B. Von der Mondfinsterniss ist nicht das geringste zu sehen gewesen weil es so gar trübe gewesen."

Possibly a thorough search might lead to the discovery of northern observations of this comet.

R. C.

OBITUARY NOTICES.

Carl Christian Bruhns was born on November 22, 1830, in the small town of Ploen in Holstein where his father was a smith. He received the usual education of an "elementary school" and was in due time apprenticed to his father. Thinking probably that he would better his fortune by leaving the small spot where he was brought up, Bruhns went to Berlin in the Spring of 1851 and worked for some time in the employment first of Borsig, afterwards of Siemens and Halske. He was not however destined to remain there long, as already the following year Encke had his attention drawn to the remarkable ability of the young mechanic in computing and engaged him as second assistant at the Observatory. Bruhns now found his time fully occupied with observing and computing, (No. 833 of the Astr. Nachr. contains his first production, elements of the planet Fortuna from three observations) as also with vigorous efforts to improve on his scanty education. Both as an observer and a computer of minor planets and comets and as a discoverer of the latter he showed himself indefatigable, as the volumes of the Astronomische Nachrichten testify. In 1854 he was appointed First Assistant at the Berlin Observatory and received the Doctor's degree in 1856 for a paper, "De planetis minoribus." In 1858 he became Privat-Docent at the University.

In 1860 Bruhns moved to Leipzig to take charge of the new University Observatory which it had been decided to build. He entered here into a field where he could display his talent of organization, which joined to his devotion to science and his gift of imbibing his pupils with the same has raised the new Leipzig Observatory to an important place among the German observatories. The observations made in Leipzig under the direction of Professor Bruhns have always been of standard excellence. Of late years he did not publish many astronomical investigations, as his time was much occupied by the duties of his professorship in the University, by his membership of the council of the "Astronomische Gesellschaft" (in which he took a lively interest from its foundation), and by works connected with meteorology and geodesy.

In 1863 Bruhns got twenty-two Royal meteorological stations started throughout Saxony, which he visited annually and whose observations he published, while he in 1878 organized a complete meteorological Bureau at the Leipzig Observatory. Of the international meteorological Congress he was also an active member. As Secretary to the permanent committee of the European measurement of degree he was one of the Editors of the Comptes rendus of this institution, and as chief of the astronomical section of the Prussian Geodetic Institute (up to 1873) he edited its publications, containing determinations of longitude, latitude and azimuth as also pendulum experiments.

Returning from his father's funeral last autumn Bruhns first showed symptoms of a serious heart disease to which he succumbed on the 25th July last after great suffering. His death is a subject of sincere regret to his numerous pupils and friends.

Dr. Carl Rudolf Powalky died in Washington on July 11, 1881. He assisted Encke for many years in the computations for the Berliner Jahrbuch and is besides known for his researches on the transits of Venus and other works. Since 1873 he resided in America where his talent for computing found him employment. He was born near Gotha in 1817.

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ON THE SOLAR PARALLAX AS DERIVED FROM THE AMERICAN PHOTOGRAPHS OF THE TRANSIT OF VENUS, 1874, DECEMBER 8–9.

BY D. P. TODD, M.A.

(An abstract of this paper has been published in the American Journal of Science, June, 1881.)

Hitherto no value of the Solar Parallax has been derived from the observations of the transit of Venus made at the American Stations in 1874. The reductions and discussions preliminary to the computation of the definitive value of the parallax obtainable from these observations are, as yet, in great part incomplete, the first part, however, containing a *General account of the operations and reduction and discussion of the observations of the Transit of Venus* is already issued.* The remaining parts are expected to contain—

II.—Observations in detail made at each station, with their reduction.
III.—Discussion of the longitudes of the stations.
IV.—Measures of the photographs, with their reduction and discussion.

Meanwhile, we have advanced to an epoch when it has become desirable that some result for the Solar Parallax should be derived from the observations of the American parties in 1874. It may be hoped that such result will help towards precise indication as to what preparations should be undertaken for the observation of the transit of 1882.

The co-efficient of elasticity which obtains in the interpretation of optic observations of transits of Venus appearing to be very great, we shall concern ourselves only with the photographic results. These are presented in Part the First, pages 104–117, in very nearly the form of equations of condition involving the correction of the difference of right ascension of the Sun and Venus, the correction of the difference of declination of the Sun and Venus, and the correction of the assumed value of the Solar Parallax.

The total number of photographs is 213, distributed among the several stations as follows :—

The Northern Stations.		*The Southern Stations.*	
Wladiwostok,	13	Kerguelen,	8
Nagasaki,	45	Hobart Town,	37
Peking,	26	Campbelltown,	32
		Queenstown,	45
		Chatham Island,	7

The residual differences (O. − C.), being given in distance, *s*, and in position-angle, *p*, every photograph gives two distinct equations of condition. These equations cannot be regarded as definitive. Three small corrections arising from the absorption of the solar and the terrestrial atmospheres have still to be applied. Their general effect on the Solar Parallax has been considered immediately preceding the equations of condition themselves, pages 102–103. The first and the second effects acting contrariwise on the Solar Parallax, we may, without very great uncertainty, disregard their combined action. The third effect should be investigated independently from the equations of condition themselves; and this again cannot advantageously be done until the definitive longitudes have been obtained, when all the effects of absorption of the solar and the terrestrial atmospheres may be most opportunely considered. We shall, therefore, disregard all these small effects, and solve the equations of condition without reference thereto.

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* The special contents of Part the First are as follow :—

Chapter I.—History of the Operations.
II.—Particulars relating to each Station.
III.—Discussion of the Photographic Operations.
IV.—Optical Observations of the Transit.
Appendix I.—Correction of Atmospheric dispersion in Astronomical Photography.
II.—Records of contact-observations.

§ 1. THE EQUATIONS OF CONDITION IN *s*.

Putting, then, $\delta\lambda_1$, $\delta\lambda_2$, ... $\delta\lambda_8$ equal to Zero, every photograph gives one equation of condition in *s* of the form,

$$0 = a\,\delta A + b\,\delta D + c\,\delta\pi - (O. - C.)$$

Treating the equations in accordance with the method of least squares, we have, for the several stations, the following partial normal equations in δA :—

W	+ 1·13 δA	+ 0·54 δD	− 1·93 δπ	− 1″·40 = 0
N	11·76	+ 17·06	− 34·59	− 55·68
P	2·52	− 2·40	+ 6·41	+ 4·59
K	0·41	− 0·03	+ 0·75	− 1·23
H	0·13	− 1·62	− 2·24	+ 2·11
C	0·53	− 1·72	− 3·22	+ 5·63
Q	6·72	+ 10·87	+ 4·81	− 32·56
Ch	+ 0·79	+ 2·01	+ 1·29	− 3·63

Also the following partial normal equations in δD :—

W	+ 0·54 δA	+ 11·64 δD	− 26·62 δπ	− 23″·29 = 0
N	+ 17·06	31·07	− 65·93	− 88·54
P	− 2·40	22·99	− 48·63	− 48·75
K	− 0·03	7·48	+ 10·67	− 11·61
H	− 1·62	36·84	+ 46·53	− 53·39
C	− 1·72	31·32	+ 39·98	− 106·73
Q	+ 10·87	37·08	+ 36·16	− 95·50
Ch	+ 2·01	+ 6·04	+ 4·68	− 11·70

Likewise the following partial normal equations in $\delta\pi$: —

W	− 1·93 δA	− 26·62 δD	+ 61·29 δπ	+ 53″·25 = 0
N	− 34·59	− 65·93	141·44	+ 183·97
P	+ 6·41	− 48·63	103·60	+ 101·88
K	+ 0·75	+ 10·67	16·75	− 18·09
H	− 2·24	+ 46·53	59·11	− 66·95
C	− 3·22	+ 39·98	53·27	− 136·06
Q	+ 4·81	+ 36·16	44·84	− 86·62
Ch	+ 1·29	+ 4·68	+ 4·21	− 9·66

The normal equations in *s* are then as follow :—

$$\begin{array}{rrrrrrrrl}
+ & 23{\cdot}99\ \delta A & + & 24{\cdot}71\ \delta D & - & 28{\cdot}72\ \delta\pi & - & 82''{\cdot}17 & = 0 \\
+ & 24{\cdot}71\ \delta A & + & 184{\cdot}46\ \delta D & - & 3{\cdot}16\ \delta\pi & - & 439{\cdot}51 & = 0 \\
- & 28{\cdot}72\ \delta A & - & 3{\cdot}16\ \delta D & + & 484{\cdot}51\ \delta\pi & + & 21{\cdot}72 & = 0
\end{array}$$

Their solution gives—

$$\begin{aligned}
\delta A &= +\ 1''{\cdot}181 \pm 0''{\cdot}202 \\
\delta D &= +\ 2''{\cdot}225 \pm 0''{\cdot}070 \\
\delta\pi &= +\ 0''{\cdot}0397 \pm 0''{\cdot}0418
\end{aligned}$$

The probable error, in distance, of a photograph with the weight unity is 0″·88. If we substitute these values of δA, δD, and $\delta\pi$, in the equations of condition, the residuals are as follow :—

Distance-Residuals—Northern Stations.

Wladiwostok		**Nagasaki**				**Peking**	
No. of Photo.	*v*	No. of Photo.	*v*	No. of Photo.	*v*	No. of Photo.	*v*
6	+ 0″·28	25	− 2″·95	57	+ 0″·60	15	− 0″·45
7	+ 0·44	26	+ 0·98	58	+ 1·44	19	+ 0·30
13	+ 0·86	28	− 0·18	59	− 0·73	21	+ 0·81
14	+ 0·48	30	− 0·97	61	− 2·67	22	+ 1·59
15	+ 0·73	31	− 1·07	62	+ 1·48	44	+ 0·21
31	− 0·96	33	− 0·17	63	− 0·73	45	+ 0·56
32	− 0·95	34	− 0·28	64	− 0·60	46	− 0·94
33	+ 0·83	35	− 0·48	65	− 2·35	49	+ 1·50
34	− 1·06	36	+ 0·33	67	+ 0·12	50	− 0·79
35	+ 0·23	37	− 0·74	74	+ 0·57	51	− 1·02
36	+ 0·10	38	− 0·50	75	− 1·53	53	− 1·07
37	+ 0·28	44	− 1·03	76	+ 0·27	54	+ 1·61
38	+ 1·26	45	+ 0·24	77	− 0·13	56	+ 0·34
		46	+ 1·00	78	− 0·77	57	− 0·02
		48	+ 1·40	79	+ 0·78	58	+ 0·87
		49	− 0·13	80	− 0·34	59	+ 0·82
		50	+ 0·04	81	+ 0·70	60	+ 0·18
		51	− 0·02	84	− 0·75	61	− 0·88
		52	+ 0·22	93	+ 0·45	63	− 0·84
		53	− 1·43	94	+ 1·70	65	+ 0·37
		54	+ 0·06	95	+ 1·06	67	− 1·95
		55	+ 0·27	96	+ 2·21	68	+ 0·68
				99	+ 0·49	69	− 0·30
						70	+ 0·73
						71	− 1·83
						72	− 2·34

Distance-Residuals—Southern Stations.

Kerguelen		Hobart Town		Campbelltown		Queenstown		Chatham Island	
No. of Photo.	v	No. of Photo.	v	No. of Photo.	v	No. of Photo.	v	No. of Photo.	v
7	+ 0″·58	9	+ 0″·01	10	− 3″·86	114	+ 0″·75	15	+ 2″·68
17	+ 1·26	10	− 0·08	11	− 2·07	115	− 0·11	16	+ 0·96
18	− 1·52	11	+ 1·20	12	− 2·72	116	+ 0·72	17	− 0·12
19	− 0·48	12	+ 1·93	17	− 1·76	117	− 0·77	24	+ 0·65
20	+ 1·68	13	+ 0·95	18	+ 0·75	118	− 3·48	25	+ 0·03
25	− 0·68	14	− 0·21	19	+ 0·53	119	− 0·18	27	− 0·03
32	+ 1·72	15	+ 1·90	23	− 0·23	120	− 0·17	29	+ 0·61
33	+ 3·12	16	+ 0·10	24	+ 0·48	122	+ 0·91		
		17	+ 1·18	28	− 2·23	123	− 2·09		
		18	− 0·46	29	− 0·72	124	+ 0·91		
		19	+ 0·63	31	− 2·34	125	− 0·51		
		22	+ 0·71	32	− 1·05	126	+ 0·60		
		23	+ 1·95	33	− 1·43	127	+ 1·61		
		24	+ 0·75	34	− 0·84	128	− 1·40		
		25	− 0·10	35	− 1·47	129	− 1·02		
		26	− 0·59	36	+ 1·31	130	+ 0·99		
		27	+ 2·57	37	− 1·14	131	+ 2·65		
		28	+ 1·98	38	− 0·48	132	− 1·05		
		29	+ 0·82	39	+ 0·84	133	− 0·72		
		30	+ 0·10	40	− 2·50	134	+ 0·50		
		32	− 1·22	41	− 0·52	135	+ 1·39		
		33	+ 1·82	42	− 0·82	139	− 1·69		
		34	+ 1·41	44	− 1·60	142	+ 0·63		
		35	+ 0·33	45	− 0·80	143	− 0·79		
		36	+ 0·93	46	− 1·54	144	+ 0·06		
		37	+ 0·67	47	− 0·10	145	+ 0·25		
		38	+ 0·17	48	− 3·82	151	+ 0·72		
		39	− 0·48	49	− 2·93	153	− 0·58		
		40	+ 2·28	50	− 2·24	154	+ 0·62		
		41	+ 2·63	51	− 1·02	155	+ 0·43		
		42	− 0·25	52	− 0·75	156	+ 1·21		
		43	+ 2·04	53	− 0·92	158	− 1·17		
		44	− 0·94			159	+ 0·49		
		45	+ 2·07			160	+ 2·83		
		46	+ 0·19			161	+ 2·09		
		47	+ 0·34			163	− 3·15		
		48	+ 1·20			164	+ 1·63		
						165	+ 0·91		
						166	+ 0·97		
						167	− 2·14		
						171	+ 0·64		
						172	− 0·80		
						173	+ 1·11		
						176	− 2·27		
						177	− 0·77		

The sums of the squares of the absolute terms in the equations of condition in s are as follow :—

$[nn]_W = 52''\cdot48$
$[nn]_N = 318\cdot25$
$[nn]_P = 130\cdot18$

$[nn]_K = 37''\cdot02$
$[nn]_H = 115\cdot65$
$[nn]_C = 414\cdot46$
$[nn]_Q = 337\cdot63$
$[nn]_{Ch} = 27\cdot83$

$[nn] = 1433\cdot50$

The sums of the squares of the outstanding residuals in s are as follow :—

$[vv]_W = 7''\cdot14$
$[vv]_N = 52\cdot47$
$[vv]_P = 29\cdot28$

$[vv]_K = 20''\cdot44$
$[vv]_H = 59\cdot74$
$[vv]_C = 95\cdot16$
$[vv]_Q = 85\cdot67$
$[vv]_{Ch} = 8\cdot91$

$[vv] = 358\cdot81$

§ 2. THE EQUATIONS OF CONDITION IN p.

Putting, as before, $\delta\lambda_1, \delta\lambda_2, \ldots\ldots \delta\lambda_8$ equal to Zero, every photograph gives also one equation of condition in p of the form,

$$0 = a'\,\delta A + b'\,\delta D + c'\,\delta\pi - (O'. - C'.)$$

We have, then, for the several stations, the following partial normal equations in δA :—

W	+ 562677 δA	− 42142 δD	− 6702·51 δπ	− 5882′·5 = 0
N	1525514	− 943839	+ 33212·89	− 20883·0
P	1010831	+ 126567	− 17987·83	− 2709·4
K	338196	− 1418	+ 5587·49	− 8511·8
H	1732884	+ 88087	− 44440·83	− 45281·6
C	1449439	+ 79151	− 37568·07	− 35839·1
Q	1757927	− 592486	− 58669·33	− 19895·4
Ch	+ 304649	− 118181	− 12431·01	− 3106·6

Also the following partial normal equations in δD :—

W	− 42142 δA	+ 78028 δD	− 4374·35 δπ	+ 264′·1 = 0
N	− 943839	747247	− 30895·31	+ 11437·3
P	+ 126567	148659	− 10823·47	− 2488·5
K	− 1418	24813	+ 169·11	− 326·0
H	+ 88087	10023	− 2273·99	− 2368·6
C	+ 79151	33367	− 2147·88	− 957·5
Q	− 592486	424281	+ 20370·42	+ 4412·0
Ch	− 118181	+ 54952	+ 4882·36	+ 469·3

Likewise the following partial normal equations in $\delta\pi$:—

W	− 6702·51 δA	− 4374·35 δD	+ 397·43 δπ	+ 81′·1 = 0
N	+ 33212·89	− 30895·31	1379·01	− 356·0
P	− 17987·83	− 10823·47	873·30	+ 185·8
K	+ 5587·49	+ 169·11	94·90	− 135·9
H	− 44440·83	− 2273·99	1139·77	+ 1161·9
C	− 37568·07	− 2147·88	974·15	+ 930·3
Q	− 58669·33	+ 20370·42	1960·55	+ 662·8
Ch	− 12431·01	+ 4882·36	+ 507·65	+ 121·6

The normal equations in p are then as follow :—

$$\begin{array}{rlrlrlrl}
+\ 8682117 & \delta A & -\ 1404261 & \delta D & -\ 138999{\cdot}20 & \delta\pi & -\ 142109'{\cdot}4 & = 0 \\
-\ 1404261 & \delta A & +\ 1521370 & \delta D & -\ 25093{\cdot}11 & \delta\pi & +\ 10442{\cdot}1 & = 0 \\
-\ 138999{\cdot}20 & \delta A & -\ 25093{\cdot}11 & \delta D & +\ 7326{\cdot}76 & \delta\pi & +\ 2651{\cdot}6 & = 0
\end{array}$$

Their solution gives—

$$\begin{aligned}
\delta A &= +\ 1''{\cdot}109 \ \pm\ 0''{\cdot}109 \\
\delta D &= +\ 0''{\cdot}637 \ \pm\ 0''{\cdot}224 \\
\delta\pi &= +\ 0''{\cdot}0252 \pm\ 0''{\cdot}0595
\end{aligned}$$

The probable error, in position-angle, of a photograph with the weight unity is $3'{\cdot}447$. Substituting these values of δA, δD, and $\delta\pi$, in the equations of condition, the residuals are as follow :—

Position-Angle-Residuals—Northern Stations.

Wladiwostok		Nagasaki				Peking	
No. of Photo.	v'	No. of Photo.	v'	No. of Photo.	v'	No. of Photo.	v'
6	+ 0'·3	25	− 4'·7	57	− 2'·9	15	+ 7'·3
7	+ 6·2	26	− 10·9	58	+ 6·7	19	+ 4·5
13	+ 5·7	28	− 10·5	59	− 3·0	21	− 1·8
14	− 1·3	30	− 7·2	61	+ 1·6	22	+ 5·7
15	− 8·5	31	− 7·2	62	+ 3·8	44	+ 0·5
31	− 0·8	33	+ 4·0	63	+ 2·6	45	+ 2·8
32	− 3·0	34	+ 4·3	64	− 0·3	46	− 1·7
33	+ 6·6	35	+ 4·9	65	+ 6·4	49	+ 4·9
34	+ 0·5	36	− 0·4	67	+ 2·1	50	+ 1·7
35	+ 6·6	37	+ 3·8	74	− 2·4	51	+ 2·0
36	+ 1·4	38	− 2·0	75	− 10·9	53	+ 4·4
37	+ 8·6	44	0·0	76	− 0·9	54	+ 5·8
38	− 2·4	45	− 1·3	77	+ 9·9	56	+ 2·2
		46	+ 6·7	78	− 0·2	57	+ 3·1
		48	+ 1·1	79	+ 3·2	58	+ 5·1
		49	− 1·5	80	− 1·8	59	+ 3·2
		50	+ 6·8	81	− 3·6	60	+ 2·5
		51	+ 4·3	84	− 2·1	61	+ 6·6
		52	+ 1·7	93	− 2·0	63	+ 3·7
		53	− 2·2	94	− 0·8	65	+ 3·9
		54	− 1·7	95	+ 1·4	67	+ 10·1
		55	− 2·1	96	+ 0·5	68	+ 4·1
				99	− 4·2	69	0·0
						70	+ 4·1
						71	+ 6·3
						72	− 3·3

Position-Angle-Residuals—Southern Stations.

Kerguelen		Hobart Town		Campbelltown		Queenstown		Chatham Island	
No. of Photo.	*v′*	No. of Photo.	*v′*	No. of Photo.	*v′*	No. of Photo.	*v′*	No. of Photo.	*v′*
7	− 3′·6	9	− 7′·0	10	+ 3′·1	114	+ 4′·8	15	+ 5′.1
17	+ 3·5	10	+ 2·7	11	+ 2·3	115	− 0·5	16	− 1·5
18	− 6·0	11	+ 3·5	12	− 1·5	116	− 1·1	17	+ 5·9
19	− 0·2	12	− 7·0	17	− 2·6	117	+ 0·5	24	+ 0·4
20	+ 7·5	13	+ 0·4	18	+ 4·1	118	+ 0·6	25	+ 6·6
25	− 4·4	14	+ 3·4	19	− 8·7	119	− 1·8	27	− 7·8
32	− 3·8	15	− 2·2	23	− 0·3	120	+ 9·8	29	− 2·9
33	− 4·8	16	− 0·7	24	− 13·6	122	+ 1·2		
		17	− 2·5	28	− 3·9	123	− 0·3		
		18	− 3·6	29	− 8·5	124	− 1·1		
		19	− 9·0	31	− 2·3	125	+ 4·6		
		22	− 3·6	32	− 10·9	126	+ 1·2		
		23	− 1·8	33	+ 11·0	127	− 0·2		
		24	+ 1·9	34	− 2·1	128	+ 1·9		
		25	+ 3·3	35	− 8·0	129	− 2·4		
		26	− 6·8	36	− 6·7	130	− 1·4		
		27	− 11·2	37	+ 3·2	131	− 3·6		
		28	+ 1·2	38	− 3·0	132	+ 2.1		
		29	− 0·9	39	− 3·5	133	+ 4·2		
		30	+ 2·4	40	+ 2·3	134	− 2·5		
		32	+ 7·1	41	+ 5·0	135	− 4·8		
		33	− 4·9	42	− 9·4	139	+ 5·5		
		34	− 2·4	44	+ 0·2	142	− 1·4		
		35	− 4·5	45	− 5·5	143	+ 3·5		
		36	+ 7·4	46	− 3·0	144	− 3·1		
		37	− 8·3	47	− 4·9	145	− 2·8		
		38	+ 0·6	48	+ 3·8	151	− 0·5		
		39	− 4·0	49	+ 13·1	153	+ 11·5		
		40	+ 4·2	50	+ 6·2	154	− 8·1		
		41	− 1·8	51	− 2·4	155	− 2·5		
		42	− 6·1	52	+ 1·0	156	+ 2·1		
		43	+ 2·0	53	+ 6·7	158	+ 4·0		
		44	+ 0·8			159	− 13·5		
		45	− 1·8			160	− 5·2		
		46	+ 1·8			161	− 4·4		
		47	− 6·7			163	+ 9·8		
		48	− 6·4			164	+ 16·5		
						165	+ 0·8		
						166	− 5·6		
						167	+ 2·6		
						171	− 4·2		
						172	+ 1·7		
						173	+ 6·5		
						176	+ 3·7		
						177	− 2·8		

The sums of the squares of the absolute terms in the equations of condition in p are as follow :—

$[n n']_{W} = 358''{\cdot}65$
$[n'n']_{N} = 1271{\cdot}49$
$[n'n']_{P} = 269{\cdot}08$

$[n'n']_{K} = 381''{\cdot}20$
$[n'n']_{H} = 1924{\cdot}85$
$[n'n']_{C} = 2044{\cdot}68$
$[n'n']_{Q} = 1462{\cdot}97$
$[n'n']_{Ch} = 220{\cdot}70$

$[n'n'] = 7933{\cdot}62$

The sums of the squares of the outstanding residuals in p are as follow :—

$[v'v']_{W} = 323''{\cdot}65$
$[v'v']_{N} = 972{\cdot}02$
$[v'v']_{P} = 519{\cdot}77$

$[v'v']_{K} = 174''{\cdot}34$
$[v'v']_{H} = 840{\cdot}69$
$[v'v']_{C} = 1236{\cdot}90$
$[v'v']_{Q} = 1232{\cdot}09$
$[v'v']_{Ch} = 176{\cdot}04$

$[v'v'] = 5475{\cdot}50$

§ 3. FINAL VALUES OF δA, δD, AND $\delta\pi$.

Some of the probable errors which have been deduced have every appearance of being illusory. Their magnitude has, no doubt, been greatly increased by the course which we have been obliged to pursue of assuming the error of longitude of the several stations equal to Zero. The longitudes actually adopted in the reductions are given at page 21 as follow :—

Wladiwostok,	8ʰ	47ᵐ	30ˢ·9	Kerguelen,	4ʰ	40ᵐ	18ˢ·1
Nagasaki,	8	39	30·6	Hobart Town,	9	49	20·5
Peking,	7	45	47·9	Campbelltown,	9	50	0·1
				Queenstown,	11	14	40·4
				Chatham Island,	12	13	11·8

All these are longitudes east from Greenwich, and only Wladiwostok and Nagasaki are definitive.

A small number of the photographs give indication of accidental error, which must be looked for as well, in the processes of obtaining the values of s and p from the photographic plates as in the computation from the tabular elements of comparison. This matter, however, is not open to investigation until Part the Fourth is published. Possibly in this way some of the larger residuals may be cut down, and the probable errors of the separate results also diminished.

But, even with the application of all these corrections, the residuals must still remain so rough that, with so small a number of equations, it may well be doubted whether any trustworthy absorption-corrections will be derivable from the equations themselves. I have no doubt that the value of similar photographic work in the future will be greatly enhanced if the exposures are effected by an observer located near the heliostat, and watching the Sun for moments of favourable definition.

Another unfavourable consideration—it has been necessary to give all these photographs equal weight in this solution, no data being yet available for deciding on their relative worth. It seems as if each picture should have a "photographic weight," so to say:—that is, a weight depending on its excellence as a simple picture. And the measures, too, of the plates are observations; and, if any variation is remarked in the subjective or objective conditions affecting their measurement, they ought to have weights just like any other observations. At the very least, each station should have had a summed weight, depending upon the number and worth of the photographs taken thereat.

The best that we can now do, however, is to combine the results in accordance with the probable errors just as they are, thus giving for δA:—

From solution in s, $\delta A = + 1''\cdot181 \pm 0''\cdot202$
From solution in p, $\delta A = + 1''\cdot109 \pm 0''\cdot109$
Final value, $\delta A = + 0''\cdot075 \pm 0''\cdot006$

and for δD:—

From solution in s, $\delta D = + 2''\cdot225 \pm 0''\cdot070$
From solution in p, $\delta D = + 0''\cdot637 \pm 0''\cdot224$
Final value, $\delta D = + 2''\cdot083 \pm 0''\cdot067$

and for $\delta\pi$:—

From solution in s, $\delta\pi = + 0''\cdot0397 \pm 0''\cdot0418$
From solution in p, $\delta\pi = + 0''\cdot0252 \pm 0''\cdot0595$
Final value, $\delta\pi = + 0''\cdot035 \pm 0''\cdot034$

The assumed value of π being $8''\cdot848$, we have, finally, for the mean equatoreal horizontal parallax of the Sun, as derived from the American photographs of the Transit of Venus in 1874,

$$8''\cdot883 \pm 0''\cdot034$$

corresponding (if we adopt the dimensions of the earth given by Colonel A. R. Clarke[*]), to a distance between the centres of the Sun and Earth equal to:—

148,103,000 kilometers = 92,028,000 miles.

[*] Geodesy . . . . Oxford, Clarendon Press, 1880, page 319.

LIST OF RED STARS, OBSERVED AT THE WASHBURN OBSERVATORY, UNIVERSITY OF WISCONSIN, MADISON.

By **Edward S. Holden.**

The following list of 77 Red Stars, 26 of which are new, includes those stars found in the Zones up to this time, and those specially looked up, for purposes of comparison, by Mr. S. W. Burnham and myself. Although the list is short it contains a few very fine stars, the most interesting being:—

Nova,	1^{h}	48^{m}	45^{s}	+	58°	40′
β,	13	42	15	—	27	46
Birmingham,	20	36	33	+	47	37

Name.	R.A. 1880.			Decl. 1880.		Date: 1881.		Remarks.
Nova, . . .	1^{h}	48^{m}	45^{s}	+58°	40′	July,	17	Fine red star; 9 mag.
Nova, . . .	2	42	5	+57	21	„	28	Good red star; 9 mag.
B. 50, . . .	2	43	43	+57	50	„	28	Not very red; 7–8 mag.
B. 242, . . .	10	31	38	—12	46	May,	15	Good red star.
B. 243, . . .	10	34	54	+ 0	3	„	14	Not red; 9 mag.
B. 248, . . .	10	45	47	—20	37	„	15	Fine full red. A star 9–10 mag. in p = 90°, s = 30″.
B. 253, . . .	10	59	33	+ 0	3	„	14	No red star seen in this place.
h. 506, . . .	11	32	26	+39	51	„	14	Yellowish-red star.
B. 266, . . .	11	39	42	+48	27	„	14	χ *Ursæ* yellowish-red only.
B. 269, . . .	11	51	59	+ 4	10	„	14	Yellowish-red only.
B. 277, . . .	12	19	7	+ 1	27	May,	1	Very full red.
B. 277, . . .						„	14	Fine red.
B. 281, . . .	12	24	14	+ 5	5	„	14	Reddish; 8·0 mag.
B. 286, . . .	12	34	56	+ 0	2	„	14	No red star in this place.
B. 288, . . .	12	38	16	— 0	50	„	14	Do.
B. 292, . . .	12	44	34	— 0	6	„	14	Do.
B. 299, . . .	12	52	10	+18	25	„	14	Reddish; not red and not "double."
B. 309, . . .	13	25	43	— 5	38	„	15	Strong yellow; very little red.
Burnham's Nova, .	13	42	15	—27	46	„	15	Splendid red star.
B. 317, . . .	13	58	41	+ 0	7	„	14	Yellowish; not full red.
B. 321, . . .	14	4	18	—15	44	„	15	Strong yellow; very little red.
B. 321, . . .						„	29	Strong red yellow; 5–6 mag.
h. 1249, . . .	14	10	25	—15	58	„	24	Reddish; 8·8 mag. A star 11 mag. in p = 180°, s = 8″
B. 327, . . .	14	18	24	+ 8	38	„	11	Yellowish red; not red.
B. 327, . . .						„	14	Fine yellow; not red.
B. 328, . . .	14	18	47	+26	15	„	11	Full red; 8 mag.
B. 328, . . .						„	14	Fine red.
B. 329, . . .	14	23	24	— 5	27	„	11	A little reddish.
B. 329, . . .						„	15	Not red; a little reddish.
Nova, . . .	14	33	58	—14	47	„	29	Red; 8 mag.
Nova, . . .	14	51	9	—11	57	„	29	Strong reddish yellow; 7–8 mag.
B. 343, . . .	14	57	3	—24	48	„	15	Not red.
B. 344, . . .	14	59	56	—15	47	„	15	Not red; strong yellow.
Nova = B.A.C. 4984,	15	2	52	—23	31	„	22	Red; 7·5 mag.
Nova, . . .	15	15	34	—28	45	„	22	Red; 8·5 mag.
B. 355, . . .	15	29	45	—27	44	„	15	Not a red star.
Nova, . . .	15	31	....	—12	40	„	29	Reddish; 8·3 mag.
Nova = 43 Libræ, .	15	35	20	—19	17	„	18	Strong reddish-yellow.
Nova, . . .	15	41	34	—19	47	„	29	Reddish; 8 mag.
Nova = B.A.C. 5347,	16	1	49	—26	0	June,	2	Strong red-yellow; 6·5 mag.
B. 369, . . .	16	2	11	+22	9	May,	14	Not red; straw colour.
Nova, . . .	16	2	27	—26	8	June,	2	Reddish-yellow; 7·5 mag.
B. 372, . . .	16	3	35	+ 1	8	May,	14	Not red; lemon-yellow.
Nova, . . .	16	14	20	—34	0	June,	2	Red; 9 mag.

Name.	R.A. 1880.			Decl. 1880.		Date: 1881.		Remarks.
Nova,	16h	32m	30s	−12°	5′	May	28	Red; 8 mag.
Nova,	16	44	51	− 0	15	„	22	Dull red; 8 mag.
Nova,	17	9	25	−15	6	„	29	Red-yellow star; 7·5 mag.
B. 407,	17	13	44	+ 2	17	„	14	Red; 7 mag.
Nova,	17	23	32	−33	58	June,	13	Good red star; 9 mag.
Nova,	17	28	13	−33	25	„	13	Red; 8·5 mag.
B. 413,	17	28	28	+12	36	May,	14	No red star in this place.
B. 416,	17	35	25	+31	16	June,	5	Reddish-yellow; 6·5 mag.
Nova,	17	41	26	− 3	36	May,	20	Red; 8 mag.
Nova,						„	23	Red; 8 mag.
Nova,	17	46	0	−34	47	„	20	The s. p. star of M. 7. It is of quite a different colour from the others. Reddish-yellow.
B. 422,	17	52	2	+ 2	44	„	14	Yellowish-red.
B. 424,	17	54	44	−27	47	„	20	Dull red; not "beautiful ruby."
Nova,	18	7	24	−29	52	June,	19	Reddish; 8 mag.
B. 431,	18	7	50	+22	48	May,	14	Pale yellow; not red.
Nova,	18	8	1	−18	57	June,	13	Dull red; 8 mag.
Nova,	18	11	20	−18	18	May,	20	Do.
B. 435,	18	13	19	+ 0	48	„	14	Faintly reddish.
B. 436,	18	16	0	+ 0	6	„	14	Do.
B. 437,	18	16	33	+25	0	„	14	No red star 7·5 mag. here.*
B. 448,	18	28	9	+36	54	„	14	Fine red; not "crimson."
B. 456,	18	36	9	+ 0	2	„	14	Yellowish.
B. 458,	18	38	40	+36	51	„	14	No really *red* star here.
B. 465,	18	46	46	+ 9	5	„	14	A red star, 8 mag., near this place.
B. 473,	18	51	26	+ 0	18	„	14	Red.
B. 475.	18	52	4	+14	12	„	14	Good red star; it has a companion 30″ off of a different colour.
B. 487,	19	3	37	+23	59	„	14	Yellowish-red; companion not specially blue.
Nova = O.Σ.(app.) 181,	19	15	15	+26	26	„	14	One component red.
Nova = 4 Vulpeculæ,	19	20	12	+19	34	„	14	Reddish.
B. 494 = 3 Cygni,	19	20	29	+24	42	„	14	Fine yellow-red star.
B. 495,	19	21	4	+19	34	„	14	Red.
B. 497,	19	21	38	+35	55	„	14	Yellowish-red.
B. 509,	19	36	22	+32	20	„	14	Red.
B. 511,	19	39	1	+12	57	„	14	Reddish.
Nova = h. 1470,	19	59	19	+37	59	„	24	Reddish star; blue companion.
B. 553,	20	15	54	+47	31	June,	17	Red; 8 mag.
Birmingham,	20	36	33	+47	37	„	17	Blood red; 8·7 mag.
Nova = h. 980,	23	5	8	+ 4	21	May,	25	Reddish; 8 mag.
B. 656,	23	52	19	+50	43	July,	17	Vivid red; 7 mag.

* [Schj. 211a. Always seen as a white star at Dunsink. Probably there is some error in Secchi's position.—Editors.]

MERIDIAN OBSERVATIONS OF COMET *b* 1881.

Made with the Troughton and Simms Meridian Circle at Dun Echt, by J. G. Lohse.

(Communicated by the Earl of Crawford and Balcarres.)

Date, 1881.	Dun Echt Mean Time.			App. α.			App. δ.			
June 25,	11h	25m	56s	5h	42m	52s·93	+	53°	22′	16″·8
27,	11	28	1		52	51·30		60	14	29·9
28,	11	29	58		58	45·49		63	10	53·5
29,	11	32	37	6	5	21·19		65	48	51·4
30,	11	36	2		12	43·58		68	10	1·3
July 1,	11	40	18		20	57·25		70	15	44·5
4,	11	59	3		51	34·70		75	13	28·9
7,	12	28	3	7	32	29·26		78	35	19·2
14,	14	8	0	9	40	13·51	+	82	3	34·7

BEOBACHTUNGEN DES COMETEN *b* 1881, AUF DER KÖN. STERNWARTE ZU GÖTTINGEN.

Mitgetheilt von Professor Dr. KLINKERFUES.

1881.	Mittl. Zeit Göttingen.	Comet − *.		Comet.		Vergleichstern.	Beobachter.	Beobachtet am.
		Δα	Δδ	α app.	δ app.			
Juni, 23,	12ʰ 22ᵐ 35ˢ	+ 0ᵐ 37ˢ·08	+ 20′ 43″·8	5ʰ 35ᵐ 55ˢ·97	+ 45° 8′ 7″·2	Arg. Oeltz. 6112	H	Kreismicr. des 6 füss. Merz Refr.
„ 26,	10 44 42	+ 6 50·74	− 7 10·4	5 47 17·16	+ 56 45 31·9	„ 6209	L	Do.
„ „	11 26 40	− 59 33·70	− 1° 43 8·4	5 47 26·13	+ 56 51 23·9	Berl. Sternv. 394	L	Repsold'schen Meridiankreise.
„ 27,	10 42 45	+ 2 19·99	+ 10 6·7	5 52 17·04	+ 60 2 10·4	Arg. Oeltz. 6342	L	Kreism. d. 6 f. Merz.
„ „	11 27 57·7	− 1ʰ 40 17·16	+ 1 8 27·4	5 52 40·41	+ 60 7 37·0	Berl. Sternv. 399	L	Repsold'schen Meridiankr.
„ „	11 27 57	− 54 19·44	+ 1 33 6·8	5 52 40·39	+ 60 7 38·9	„ 394	H	Reichenbachschen Meridiankr.
„ 29,	10 58 43	− 16·99	− 5 3·9	6 4 57·14	+ 65 40 7·2	Arg. Oeltz. 6594	L	Kreism. d. 6 f. Merz.
„ 30,	10 7 8	+ 4 34·99	− 1 29·0	6 11 58·38	+ 67 54 45·2	Arg. Zone 67,422	H	Do.
„ „	11 35 54·4	− 28 25·57	——	6 12 28·00	——	Berl. Sternv. 391	H	Passage Instrument.
„ „	11 35 54·5	− 1 6 2·54	− 36 28·1	6 12 28·13	+ 68 5 50·2	„ 116	L	Repsold'schen Mer. Kr.
Juli 1,	11 5 15·3	+ 3 46·73	+ 8 56·7	6 19 10·86	+ 70 8 25·5	Arg. Zone 70,402	M	Kreism. d. 6 f. Merz.
„ „	11 40 10·2	− 20 12·85	+ 1 10 15·7	6 20 40·69	+ 70 11 38·7		M	Reichenb. Mer. Kr.
„ „	11 40 9·8	− 20 13·88	——	6 20 39·66	——	Berl. Sternv. 391	H	Passage Instr.
„ „	11 40 8·4	− 20 14·31	+ 1 10 16·1	6 20 39·25	+ 70 11 38·3		L	Reps. Mer. Kr.
„ „	13 7 59	− 2 13·29	− 17 14·7	6 21 9·58	+ 70 18 38·4	Arg. Oeltz. 6920	L	Kreism. d. 6 f. Merz.
„ 2,	10 3 0	+ 2 35·89	+ 5 10·9	6 29 5·61	+ 71 55 58·6	„ 6978	L	Do.
„ „	11 8 9	+ 3 37·1	+ 9 49·6	6 29 33·53	+ 72 0 26·6	„ „	H	Do.
„ „	11 47 3	——	+ 3 52 15·5	——	+ 72 3 47·2	Berl. Sternv. 391	L	Reps. Mer. Kr.
„ „	12 25 54	+ 3 34·41	+ 15 50·1	6 30 4·23	+ 72 16 27·1	Arg. Oeltz. 6978	H	Kreism. d. 6 f. Merz.
„ 4,	11 58 47·3	+ 1 27 19·63	+ 8 9·6	6 51 10·94	+ 75 5 44·6	Berl. Sternv. 92	L	Reps. Mer. Kr.
„ 5,	12 7 11·4	− 1 1 1·26	+ 20 49·0	7 3 32·86	+ 76 27 47·8	„ 406	L	Do.
„ „	12 7 13·4	− 1 0 59·50	+ 20 55·8	7 3 35·62	+ 76 27 53·3	„ 406	H	Reichenb. Mer. Kr.
„ 7,	12 27 40·2	− 49 14·20	+ 1 6 6·3	7 31 56·67	+ 78 13 34·0	„ 393	L	Repsold, Mer. Kr.

Als Beobachter bedeutet H, Calculator Heidorn, L, Dr. Lakits und M, stud. astr. Meyer.

ON THE TELEGRAPHIC TRANSMISSION OF ASTRONOMICAL DATA.

In the "Science Observer," No. 33–34, Messrs. S. J. Chandler, Jr., and J. Ritchie, Jr., have described a simple but ingenious method of telegraphing elements and ephemerides of comets or planets, accurate positions, or simple announcements of discoveries. This method has been tested on comets *a*, *b*, and *c*, 1881, arrangements having been made with Lord Crawford for exchanging telegrams between Boston and Dun Echt. The system has proved perfectly satisfactory and the inventors have now decided to publish it for the benefit of astronomers who may have occasion to use such a system. We shall here give a short abstract of the method, referring such of our readers who may intend to adopt the system, to the detailed description in the "Science Observer." A few copies of the latter have been printed on thick paper for observatory use and will be sent post free to anyone sending one shilling (or one mark) to Mr. J. Ritchie, Box 2725, Boston, Mass.

The plan of the *Science Observer Code* is as follows. The code is a dictionary cipher; Worcester's comprehensive Dictionary, Boston, 1876, being selected as the most available.* This book has more than 390 pages, and has generally more than a hundred words on a page. Any integral number up to 39000 can therefore be represented by a single word, by making the two digits on the right (the tens and units) of the proposed number correspond to the numerical order of the word on the page, and the three places on the left, to the number of the page. Thus 349° 12′ can be represented by the 12th word on page 349, and 16,718 by the 18th word on page 167. April 14, $10^h\ 48^m$ = April 14·45 being the 134th day of the year (135th of leap year) can be represented by the 45th word on page 134, and so on. A control-word is introduced to ensure correctness of transmission and translation. The following is a scheme of a seventeen-word despatch, giving elements and ephemeris of a comet.

1. Time of perihelion passage = T
2. Distance of perihelion from node = $\omega = \pi -$ ☊
3. Longitude of node = ☊
4. Inclination (from 0° to 180°) = i
5. Perihelion distance = q
6. Control word = ¼ of sum of 1 to 5 inclusive.
7. First date of Ephemeris and light for that date.
8. First RA
9. First NPD
10. Second RA
11. Second NPD
12. Third RA
13. Third NPD
14. Fourth RA
15. Fourth NPD

   Intervals of four days.

16. Last day of Ephemeris and light for that date.
17. Dates of the observations from which the orbit is computed.

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* Mr. Ritchie will send a copy of this dictionary, post free, on receipt of 1½ dollar.

Example, comet *b* 1881 (see above, p. 142).

T = June 16·40 Gr. M. T. = 167 40 = elegy.
ω = 354° 9′ = 354 09 = pyrrhic.
☊ = 270 59 = 270 59 = linger.
i = 63 31 = 63 31 = armillary.
q = 0·7339 = 73 39 = bass.
Control-word = ¼ (928 78) = 232 20 = illiteracy.
June 30 = 30, Light = 1·00 = 1 00, therefore 301 00 = needy.
RA 93°39′ = 93 39 = calmness.
NPD 21°18′ = 21 18 = supervention.
RA 103 37 = 103 37 = chary.
NPD 14 27 = 14 27 = stone-work.
RA 118 6 = 118 06 = comprehensibleness.
NPD 10 24 = 10 24 = staggard.
RA 136 29 = 136 29 = curse.
NPD 8 22 = 8 22 = spondaical.
July 12 = 12, and Light = 0·30, therefore 120 30 = confest.
First observation May 29 = 149
Second obs. June 23 (interval being more than ten days) = 0
Third obs. June 25 (interval 2 days) = 2
} = 149 02 = diapente.

As the dictionary proper begins on p. 41, the pages from 0 to 41 are supplied by using for them pp. 400 to 441. The control-word has been found of great use in detecting errors while simple inspection corrected others; thus in sending the elements and ephemeris of comet *c* from Dun Echt to Boston (above, p. 164) the first date of the ephemeris, "hair," was changed into "hail," which error was easily found at Boston, and one of the Right Ascensions, "centaur," became "cettaur," which was corrected by inspection and the correction proved by differencing. It often happens that two or more words are alike in the dictionary, e.g. "love" which is both a noun and a verb. In case the required word is the second or third of the series, the error implied by the use of the word without designating which of the three is meant, cannot be more than 2′ or 0·02 of a day, but if special accuracy is desired, it is merely necessary to place after the word in question "second," "third," &c., designating its order in the series. The desired word will often happen to have more than ten letters, in which case (as the cable companies charge it as two words), the next word may be used, introducing only a slight error.

It might in some cases be desirable to telegraph an accurate position of a comet, for which purpose the *Science Observer Code* also offers advantages. The following is an example of a six-word position message supposing the accurate position to be:—

June 23. $19^h\ 38^m\ 45^s$ G. M. T., RA $5^h\ 36^m\ 7^s.4$, Dec. + 46° 36′ 14″,
or June 23·8185 RA 84° 1′ 51″ NPD 43° 23′ 46″,

this would be telegraphed as follows:—

Month = June.
Date 23·818 = 238 18 = inclinable.
RA 84° 1′ = 84 01 = boom.
NPD 43 23 = 43 23 = absorbent.
Seconds of RA (51″ = $3^s.4$) = 34
Seconds of NPD 46″ = 46
Time 0·0005 = 5
} = 34465 = 344 65 = pricket.
Control-word = ¼ (710 07) = 177 52 = eventually.

If only an approximate position is to be sent, the word "Zero" is substituted for the fifth word. In the above example the Control-word would then be = ¼ (365 45) = 91 36 = button-hole.

It is also possible by means of this code to give the particulars of the discovery of a comet, planet, or other celestial body in a message of eleven words only, and in such message to state the position and motion more accurately than by the present method which requires twenty-six words and is liable to many errors. A discovery could be announced thus :—

1. Nature of object.
2. Name of Discoverer.
3. Brightness in stellar magnitudes.
4–9. Six words indicating position.
10. Daily motion in RA.
11. Daily motion in NPD.

Daily motions with a negative sign should be subtracted from 360° and the difference used in its place. Thus a motion of — 0°27′ in RA would be expressed by 359° 33′ (rascallion). Errors such as occurred in the telegrams from Cordoba and South Africa about comet *b* 1881, would never be found in a message arranged in this way.

Messrs. Chandler and Ritchie conclude the description of their system by inviting suggestions from practical astronomers. Other formulæ for special purposes could easily be arranged, but the inventors have deemed it better not to encumber the general statement of the capabilities of the system by a number of special forms of message. For the present, Worcester's dictionary will be found to be fairly well adapted to the work, and the inconvenience arising from its imperfections are but trifling. There are doubtless many other dictionaries equally suitable for the purpose, but it is advisable to have a uniform code-book, in order that it may not be necessary to translate the message from one code to another, should the receiver desire to transmit it further.

MERIDIAN OBSERVATIONS OF COMET *c* 1881 (SCHAEBERLE).

Made at Dunsink, by J. L. E. DREYER.

1881.	Dublin M. T.	App. α.	App. δ.
Aug. 10	10^{h} 23^{m} 53^{s}	7^{h} 42^{m} $5^{s}\cdot00$	+ 51° 38′ 57″·9
12	10 42 32	8 8 39·28	52 27 55·1

The declinations have not been corrected for parallax. On both nights clouds interfered with the observations.

MERIDIAN OBSERVATIONS OF COMET *c* 1881 (SCHAEBERLE).

Made with the Troughton and Simms Meridian Circle at Dun Echt, by J. G. LOHSE.

(Communicated by the Earl of CRAWFORD and BALCARRES.)

Date, 1881.	Dun Echt Mean Time.	App. α.	App. δ.
Aug. 5	9^h 57^m 36^s	6^h 55^m 57^s·44	+ 48° 48′ 34″·8
9	10 16 29	7 30 40·04	+ 51 7 48·4

OBSERVATIONS OF ENCKE'S COMET.

Made with the filar-micrometer of the Dun Echt Refractor, by J. G. LOHSE.

(Communicated by the Earl of CRAWFORD and BALCARRES.)

Date. 1881.	Dun Echt Mean Time.	Comet – * Δα.	Comet – * Δδ.	α Comet.	Parall.	δ Comet.	Parall.
Aug. 28,	14^h 14^m 40^s	+ 27^s·54	+ 5′ 59″·3	4^h 4^m 28^s·93	– ^{s}·26	+ 34° 11′ 18″·4	+ 3″·8
„ 29,	14 34 46	– 30·46	– 2 20·8	4 7 59·70	– ·25	+ 34 31 51·2	+ 3·8

Aberration-time and parallax have not been applied.

ADOPTED MEAN PLACES OF COMPARISON STARS FOR 1881·0.

	α	Red.		Red.	Authorities.
Aug. 28,	4^h 3^m 57^s·37	+ 4^s·02	+ 34° 5′ 15″·6	+ 3″·5	Bonn. Beob. Bd. VI. + 34°·828
„ 29,	4 8 26·11	+ 4·05	+ 34 34 9·0	+ 3·0	B. W. IV. 117.

The observations give the following corrections to O. Backlund's ephemeris.

Aug. 28,	Corr. to α = – 41^s·57	Corr. to δ = – 1′ 23″·8
„ 29,	– 41·22	– 1 18·7

The comet, although very faint, is seen without much difficulty in a dark field, but becomes invisible on lighting up the bright wires. The observations, made under such disadvantages, are naturally uncertain, probably to an extent of several seconds, especially on August 28, when the comet was passing several rather bright stars.

RECENT LITERATURE.

"*Reports on the Total Solar Eclipses of July* 29, 1878, *and January* 11, 1880. *Issued by the U.S. Naval Observatory.*" (Washington, 1880, XIV, 426 pp. 4to, 25 plates of wood-cuts of the Corona and 30 lithographic plates). This magnificent volume, which forms Appendix III to the Washington Observations for 1876, is, with the exception of eighteen pages at the end, entirely devoted to reports and discussions on the Eclipse of 1878, and leaves all reports on previous eclipses far behind both in the fulness and number of the observations and in the number and beauty of the illustrations. The more rough sketches of the outlines of the Corona are reproduced in wood-cuts, while the finished drawings are lithographed with great care and evident conscientiousness. The various reports were prepared by most of the leading astronomers in the United States as well as by a great number of amateurs and occasional observers. They give very full details of the determinations of longitude and latitude of the stations and describe minutely what each person observed and what instrument he used. The supposed discovery of intra-mercurial planets is fully described by Messrs. Watson and Swift, but nothing new is added except that Professor Watson states distinctly that he saw θ Cancri at the same time as the object which he designates as a. After finding the second object b and recording it he ran over to Professor Newcomb and asked him to look for it, but when he came back again to his own telescope the Sun had reappeared and prevented him from looking for ζ Cancri to see if it and b were distinct objects.[*] A considerable number of casual observers were employed in sketching the Corona or in determining the exact duration of the time of totality at various points just within the limits of the zone of total obscuration. The latter kind of observation was particularly attended to in Eastern Central Texas under the able superintendence of Mr. D. P. Todd. The Corona is stated by several observers to have been more regularly round (and less square) than in 1869. Most of the drawings agree with the photographs in showing two long rays or streamers at opposite sides of the Sun and nearly in its Equator. The results of the photographs are put together in one of the lithographic plates, on which it is believed everything shown on the negatives has been faithfully reproduced. In several figures the intensity of light in all parts of the Corona is shown by means of contour lines. These were made by placing a sheet of transparent gelatine on enlarged glass-positives made from the original negatives, after which the details of the Corona were scratched on the gelatine with a needle point. The curves obtained show the enormous rapidity with which the coronal light increases as the Sun's limb is approached.

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[*] "Science" No. 85 (Feb. 26, 1881) gives a very instructive chart showing the ground covered by six observers who during totality devoted more or less time to the search for intra-mercurial planets without seeing anything. It is certainly strange, that a was not noticed by any of the three observers who must have swept over its place. The place of Swift's two objects was examined by two observers. It must however be borne in mind that most of these observers could only devote very little time to sweeping.

The spectroscope was of course extensively used during this eclipse. Professor Eastman remarks how surprisingly bright the continuous spectrum of the Corona was while the "1474" line appeared much fainter than was expected. This line he took special pains to trace as far as possible all round the Sun and found that the matter which gives rise to it was fairly uniformly distributed, the line being traced to about 12′ outside the limb. Commander Sampson (who observed with Professor Newcomb) searched specially for dark lines in the continuous spectrum of the Corona, but saw none. At the beginning of totality he saw the Frauenhofer lines reversed at the disappearing limb for about two seconds.

Special interest is attached to the endeavours to determine the character of the polarization of the light of the Corona. The report of Professor A.W. Wright of Yale College, who observed at La Junta, Colorado, gives a full description of the instruments and methods employed for this very delicate kind of observation. Before the eclipse, Professor Wright studied the various possible phases of polarization, which might appear during totality, with an apparatus which produced an artificial corona. These experiments suggested the use of a polariscope composed of a Nicol's prism before which was placed a thick quartz plate to increase the sensibility of the instrument. During the eclipse the Corona when viewed with this instrument showed two opposite quadrants of a rosy colour, strongest in the centre of each. The position of the Nicol having been carefully recorded, a comparison with the previous experiments showed with certainty that the polarization was radial. For a determination of the percentage of polarization a specially constructed polarimeter was used, in which the polarization was detected by means of a selenite plate, while its amount was ascertained by a system of four plane glass plates hinged together, the angle of inclination of which was measured by a divided arc. This apparatus was attached to a comet seeker of three inches aperture, and the distance of the point of the Corona observed from the Moon's limb could be measured by reference to lines cut in a piece of plate glass, to the centre of which the selenite plate was fixed. The results found with this instrument indicate that the polarization decreases from the Moon's limb outwards, the amount for a space between 4′ and 10′ vertically below the limb being 12 per cent. and between 12′ and 18′ 6·8 per cent. In addition to these observations Professor Wright secured during the eclipse two polariscopic photographs with a small landscape camera, in which a double-image prism was attached to the inner end of the lens-tube. First one exposure of eighty seconds was made while the prism was set so as to place the two images north and south of each other; then the plate was pushed in and the lens tube turned about 45°, after which another picture was taken with the same exposure. The photographs agree with the observations made with the polariscope (and with the photographs taken by Prof. Harkness) in showing that the polarization is radial. The photographs appear to indicate some deviation of the planes of polarization from the direction of the radii, in four regions situated some 20° from the poles, where they seem to be deflected outwards (away from the solar axis). The amount of the deflection and even its existence is subject to some uncertainty, as it may possibly be explained by certain peculiarities in the distribution of the intensity of polarization.

The eclipse of January 11, 1880, was observed at Santa Lucia Mountain near the coast of California, by Professor Frisby. The circumstances were very unfavourable, the Sun being near the horizon and totality only lasting 32ˢ. The contacts were well observed and a sketch made of the Corona which appeared narrow and without any rays.

"*Large Telescopes,*" *by Edward C. Pickering* (Proc. Amer. Acad. Vol. XVI, 6 pp.). In this paper the Author advocates the use of a large telescope placed horizontally in the prime vertical and having a plane reflector inclined to its axis by 45° placed in front of the object-glass. This reflector may revolve around an axis coinciding with that of the telescope, and as there is only one motion, flexure of the mirror need not be feared. It would however be desirable to let the mirror be movable to the extent of 5° from its central position at right angles to the meridian, as an object at the equator might then be followed for forty minutes, and this motion would probably not materially affect the flexure. Such a mounting would have many advantages over an equatoreal. Great steadiness would be secured, no large and expensive dome would be required, the mirror and object glass could be mounted on two small piers, protected by a small shed, the tube could be made of tin or other cheap material, and the eye-piece could be enclosed in a room which even might be warmed, and where the observer could sit comfortably and would probably be able to work much longer than under a dome. By means of a long handle the position of the mirror may be regulated from the eye-end and the declination of the object observed read by small telescopes. The mirror may also be moved by clockwork. If a reflector could be constructed, whose surface was the portion of a paraboloid whose abscissa equalled that of the focus, no object-glass would be required and a great loss of light would be avoided.

Such a horizontal telescope would be useful for a great many purposes, the greatest advantage being the rapidity with which a large amount of work could be produced. For sweeping for new objects it would be particularly suitable, and also to spectroscopy and photometry it could be usefully devoted, as there would be no difficulty in attaching large and complicated instruments to the stationary eye-end. The necessity of observing close to the meridian would not cause much inconvenience, as there with a large telescope would be plenty of objects to select from.

"*Observations of Double Stars made at the U.S. Naval Observatory by Asaph Hall,*" (Washington 1881, 144 pp. 4to, Wash. Obs. 1877, App. VI). This publication contains observations made from 1875 to 1880 with the 26-inch Refractor at

Washington, part of the objects being those selected by Otto Struve to be observed by several observers in order to determine their personal errors. The remainder of the objects are mostly double stars observed by the two Struves, to which were added a few of Mr. Burnham's stars, a few multiples, the companion of Sirius and the stars near the Ring Nebula in Lyra. The whole number of observations is 1614.

"*Contributions from the Washburn Observatory of the University of Wisconsin, Number* 1," (11 pp. 4to). This first number of what will undoubtedly become a very important series contains three lists of new objects; new nebulæ, new double stars, new zone doubles, all found and measured with the Clark refractor of 15·56 inches aperature since the latter part of April 1881. The first and third lists are made up from the sweeps or zones observed by either of the two observers, Holden and Burnham, principally by the former, with a Kellner eye-piece having a field of 25′·5 and magnifying 145 diameters. All the micrometric measures of double stars were made by Mr. Burnham.

"*Note on Photographs of the Spectrum of the Comet of June* 1881," by Prof. H. Draper (Amer. Journal, Aug. 1881, 2 pp.). Besides obtaining a photograph of the head and the tail to the extent of nearly 10° with an exposure of 162 minutes, Professor Draper succeeded in taking pictures of the spectrum with exposures from 180 to 228 minutes, using a two-prism spectroscope. A heavy band above *H* (divisible into lines) and two faint bands, one between *G* and *h* and another between *h* and *H* are seen on the photographs. A fuller discussion of these is to follow.

FROM DUN ECHT CIRCULAR, No. 29 (Sept. 2).

The following telegram from Kimberley, South Africa, evidently refers to Schaeberle's Comet *c* 1881, and is a further proof of the necessity of quicker and more extended intercommunication of astronomical news.

> "From Marlo Clarkson to Lord Crawford Dun Echt.
>
> Seen Comet nightly since Sunday; yesterday near ascension thirteen hours twenty, north twenty degrees, lack instrument send catalogue."

Mr. Common found Encke's Comet at $11^h\ 42^m$ p.m. on August 27 and saw it again on the 28th; it was a very faint nebulous mass, almost 2′ diameter. By the circles of the 3-foot reflector the correction to the ephemeris was — 30^s and — 3′ more or less.

From Astr. Nachrichten Circ. 5, it appears that Encke's Comet was found on Aug. 20 at Strasburg by Dr. Hartwig and Professor Winnecke, and on Aug. 24 by Director O. Struve at Pulkowa.

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DAS POSITIONSRINGMIKROMETER.

Von Dr. H. KOBOLD.

Nachdem durch Olbers' und Bessel's theoretische und praktische Arbeiten dem vorher vielfach verkannten und verschmähten Kreismikrometer der ihm gebührende Rang unter den Hülfsvorrichtungen der praktischen Astronomie erkämpft war; nachdem vor allem Fraunhofer auch die mechanischen Schwierigkeiten glücklich beseitigt hatte, sollte man annehmen dieses Mikrometer zu genauen Messungen überall dort angewandt zu sehen, wo Lichtschwäche den Gebrauch des Fadenmikrometers nicht gestattet. Wenn dem nun nicht so ist, wenn vielmehr auch heute das Ringmikrometer nur eine sehr beschränkte Verwendung findet, und seinen Resultaten nicht dasselbe Vertrauen entgegen gebracht wird, wie den mit anderen Hülfsmitteln erlangten, so liegt der Grund hiervon ohne Zweifel darin, dass die Genauigkeit der Messungen hier von gewissen äusseren Bedingungen abhängt, deren Erfüllung der Beobachter selbst durchaus nicht herbeiführen kann.

Bekanntlich hängt die Genauigkeit des Anschlusses eines Objectes an einen bekannten Stern vermittels des Kreismikrometers von der Declinationsdifferenz beider ab. Ist letztere sehr gering, so werden die Differenzen beider Coordinaten am sichersten erhalten. Die gleiche Genauigkeit vermag man bezüglich der Declinationsdifferenz auch dann noch zu erzielen, wenn jene die Grösse des Ringdurchmessers fast erreicht. Nennt man μ und μ' die von den beiden Objecten beschriebenen halben Sehnen, ϕ and ϕ' die zugehörigen halben Centriwinkel, so besteht die Relation—

$$\Delta(\delta' - \delta) = \frac{\sin(\phi \mp \phi')}{\cos\phi \cos\phi'} \cdot \Delta\mu$$

wobei angenommen ist, dass μ und μ' mit den gleichen Beobachtungsfehlern $\Delta\mu$ behaftet sind, und dass der angewandte Radius des Ringes fehlerfrei sei. Die Auflösung dieser Gleichung ergiebt nun in dem Falle, dass beide Objecte an derselben Seite vom Kreismittelpunkte das Gesichtsfeld durchlaufen, dass—

$$\Delta(\delta' - \delta) = \Delta\mu \qquad \text{für}: \phi = 0,\ \phi' = 45^\circ \qquad \delta' - \delta = 0{\cdot}29289\ r$$

wird, wobei angenommen ist, dass man das eine Object der Peripherie so nahe als möglich bringe. In dem anderen Falle; $\delta' - \delta > r$ darf man wieder $\phi = \phi'$ annehmen, weil für diese Stellung die Beobachtung am genauesten ist; dann wird aber—

$$\Delta(\delta' - \delta) = \Delta\mu \qquad \text{für}: \phi = \phi' = 26^\circ\ 33'{\cdot}9 \qquad \delta' - \delta = 1{\cdot}78884\ r$$

Nur dann also, wenn—

$$0{\cdot}29289\ r \overset{=}{>} \delta' - \delta \geqq 0 \quad \text{und} \quad 2r \overset{=}{>} \delta' - \delta \geqq 1{\cdot}78884\ r$$

ist, gehen die Beobachtungsfehler in gleichem Betrage in das Resultat über, ausserhalb dieser Grenzen aber geben sie zu noch grösseren Fehlern im Resultate Anlass. Da man nun wohl nur äusserst selten der beobachteten und auf den Aequator reducirten halben Sehnenlänge einen $0''{\cdot}1$ nicht erreichenden Fehler wird geben können, so erkennt man leicht, dass man selbst innerhalb der angegebenen engen Grenzen die 0″·1 der Declinationsdifferenz nur bei häufigen Wiederholungen der Beobachtung wird verbürgen können, während man sie in der übrig bleibenden überwiegenden Mehrzahl der möglichen Distanzen nie wird erreichen können.

Die Innehaltung der angegebenen Grenzen wird nun sicher kaum in der Hälfte der Anwendungen möglich sein, und auch dann wird man den Grenzen häufig recht nahe kommen und kaum vermeiden können zum Anschluss Sterne zu benutzen, die in Rectascension ziemlich weit abstehen. Als vielleicht unnöthigen Beleg hierfür führe ich nur an, dass unter den von Herrn Professor Auwers in No. 2383 der Astronomischen Nachrichten mitgetheilten 32 Cometenbeobachtungen nur 15 sich finden, wo der Vergleich gegen schon bekannte Sterne möglich war. Ob auch unter diesen noch solche vorkommen, die ausserhalb der aufgestellten Grenzen fallen, lässt sich leider sicht entscheiden, weil man nicht angegeben findet, an welchem Ringe des Doppelringmikrometers beobachtet wurde.

Diesen Mängeln ist nun leicht durch eine Verbindung des Kreismikrometers mit einem Positionskreise zu begegnen. Befestigt man nämlich in eine planparallele Glasplatte neben einander zwei Stahlringe, setzt diese Platte an die Stelle der gewöhnlichen Ringplatte in das Mikrometerocular und schraubt letzteres dann in einen am Ocularende des Fernrohres sitzenden Positionskreis, so hat man ein einfaches und doch sehr sicheres Hülfsmittel um je zwei Objecte, deren Declinationsdifferenz den Abstand der Kreismittelpunkte nicht übertrifft in beiden Coordinaten auf die vortheilhafteste Weise miteinander zu vergleichen. Zu dem Ende stelle man die Ringplatte durch Verdrehen im Sinne des Positionswinkels derart ein, dass die Projection jener Verbindungslinie der Kreismittelpunkte auf den Declinationskreis möglichst nahe gleich der Declinationsdifferenz der beiden Objecte werde, lasse dann unter Benutzung der Declinationsfeineinstellung des Fernrohres die beiden Objecte einmal durch die Mitte je eines der Ringe und dann möglichst nahe an den oberen und unteren Rändern passiren. Die Durchgänge der ersteren Art geben die Rectascensions-, die der letzteren die Declinationsdifferenz. Es braucht wohl kaum noch darauf aufmerksam gemacht zu werden, dass man die Vergleichung des unbekannten Objectes in der Regel leicht gegen mehrere bekannte Sterne wird ausführen können.

Ein solches Mikrometer wurde für die hiesige Sternwarte nach meiner Angabe von Herrn Mechaniker Becker in Göttingen ausgeführt. Es hat sich bisher völlig bewährt und schon häufig treffliche Dienste geleistet. Seine Anwendung ist namentlich dann durchaus nicht unbequem, wenn, wie beim hiesigen, der Positionskreis beständig am Fernrohre verbleibt und zur Aufnahme der verschiedensten Mikrometer dienen kann.

Man könnte nun versucht sein die mit diesem Positionsringmikrometer erzielten Resultate von dem Stattfinden gewisser mechanischen Bedingungen abhängig zu halten, indem man eine Beeinflussung der gemessenen Positionswinkel von einer etwaigen fehlerhaft erscheinenden Einsetzung der Ringe befürchtete darin bestehend, dass der Halbirungspunkt der Verbindungslinie der Ringmittelpunkte nicht mit dem Drehungsmittelpunkte der ganzen Mikrometervorrichtung zusammenfällt. Eine solche Beeinflussung ist aber in der That nicht vorhanden, wovon man sich leicht überzeugt, wenn man sich durch den wahren Drehungsmittelpunkt eine Parallele zur Verbindungslinie der Ringmittelpunkte gezogen denkt. Da der Parallelismus dieser Geraden in jeder Lage stattfinden wird, so muss auch die in Frage kommende Verbindungslinie der Bewegung dieser Hülfslinie also auch der der Alhidade des Kreises völlig gleichmässig folgen und wird also durch letztere zu messen sein. Etwaige die Angaben der Nonien entstellende Einflüsse hat man natürlich zuvor auf bekanntem Wege zu eliminieren.

Es erübrigt uns nun noch zu zeigen auf welchem Wege man die zur Reduction der Beobachtungen nöthigen Constanten sich verschafft. Dieselben bestehen aus den Radien der Kreise, der Entfernung ihrer Mittelpunkte und dem Nullpunkte der Positionswinkel.

Die Ringdurchmesser geben hier dieselben Methoden, die beim gewöhnlichen Kreismikrometer Verwendung finden; also diejenigen, welche zwei in Declination fast um den zu bestimmenden Durchmesser verschiedene Sterne benutzt, dann die Peters'sche aus zwei etwa in der halben Entfernung stehenden, endlich die Gauss'sche Methode. Von diesen ist hier wohl die Peters'sche vorzuziehen, weil sie zu gleicher Zeit auch den Abstand der Ringe ergiebt. Da bei derselben aber die Beobachtungsfehler, welche bei dem die Mitte der Ringe durchlaufenden Sterne begangen werden, mit ihrem vollem Gewichte in das Resultat übergehen, so wird man die Messung häufig wiederholen müssen. Bei der nach dieser Methode ausgeführten Bestimmung des hiesigen Mikrometer erhielt ich aus je 30 Messungen für die Radien der Ringe—

$$R_1 = 221''{\cdot}47 \pm 0''{\cdot}067 \qquad R_2 = 223''{\cdot}02 \pm 0''{\cdot}264$$
$$r_1 = 149{\cdot}62 \pm 0{\cdot}247 \qquad r_2 = 149{\cdot}79 \pm 0{\cdot}221$$

Der mittlere Fehler der einzelnen Messungen stellte sich auf—

$$\varepsilon = \pm 1''{\cdot}420.$$

Die Distanz der Ringmittelpunkte aus 38 Messungen, deren einzelne mit dem mittleren Fehler—

$$\pm 0^{\mathrm{r}}{\cdot}0346$$

behaftet war, ergab sich zu—

$$\varepsilon_0 = 62^{\mathrm{r}}{\cdot}443 \pm 0^{\mathrm{r}}{\cdot}0039.$$

Man erkennt leicht, dass man den so erhaltenen Werthen für die Radien bei weitem nicht die auf andere Wege erreichbare Genauigkeit zu geben vermag. Dennoch darf man sie mit vollem Vertrauen wenigstens zu einer vorläufigen Reduction benutzen, da es bei derselben fast allein auf ε_0 ankommt, während kleine Aenderungen in den Radien die erhaltenen Abstände gegen den Ringmittelpunkt im gleichen Sinne und bei richtiger Anordnung auch im gleichen Betrage beeinflussen, so dass die Differenz derselben nicht geändert wird.

Den Nullpunkt der Positionswinkel ermittelt man sehr einfach und sicher dadurch, dass nan unmittelbar vor oder nach der Beobachtung den benutzten Vergleichstern noch einmal so durch das Gesichtsfeld laufen lässt, dass er sich in beiden Ringen möglichst gleich weit vom Mittelpunkte bewege. Ergiebt dann die Reduction den Abstand in dem ersten Ringe = y_1^*, im zweiten = y_2^*, so hat man die Kreisablesung noch um—

$$\Delta\phi = \text{arc}\, tg\, \frac{y_2^* - y_1^*}{\varepsilon_0}$$

zu vermehren, vorausgesetzt dass die Beziffrierung des Kreises dem Sinne der Positionswinkel entsprechend fortschreitet.

Die Reduction der Beobachtungen ist nun nach folgenden Formeln auszuführen. Das zu bestimmende Object, etwa ein Planet, werde am Ringe 1, der Vergleichstern am Ringe 2 beobachtet, ferner seien t_1 und t_2 die Zeiten der Durchgänge durch die Meridiane der Mittelpunkte der Ringe und y_1 und y_2 die nach den gewöhnlichen Formeln berechneten Abstände gegen diese Mittelpunkte. Der Positionskreis gebe bei der Beobachtung den Winkel p an, sein Nullpunkt liege bei p_0, und endlich sei $\delta = \frac{1}{2}(\delta^p + \delta^*)$. Es wird dann—

$$\alpha^p - \alpha^* = \varepsilon_0 \cos(p_0 - p) \sec\delta + (t_1 - t_2)$$
$$\delta^p - \delta^* = \varepsilon_0 \sin(p_0 - p) + (y_1 - y_2)$$

In diesen Gleichungen ist ε_0 als positiv zu betrachten, wenn dem Mittelpunkte des Ringes 1 die grössere Rectascension entspricht.

An dem zum 6″ Refractor gehörenden Mikrometer der hiesigen Sternwarte wurde am 20 Juli der Planet (216) beobachtet. Aus 7 Vergleichungen ergab sich —

$$t_1 - t_2 = 1^{m}\ 20^{s}{\cdot}14$$
$$y_1 - y_2 = +\ 7''{\cdot}1$$
$$p_0 - p = 44^\circ\ 59'{\cdot}3$$

Hiermit wurde unter Hinzufügung des Refractionseinflusses gefunden—

1881, Juli 20. $10^{h}\ 28^{m}\ 9^{s}$ M. Z. O'Gyalla:

$$\alpha^p - \alpha^* = +\ 44^{s}{\cdot}72 + 1^{m}\ 20^{s}{\cdot}14 + 0^{s}{\cdot}04 = +\ 2^{m}\ 4^{s}{\cdot}90$$
$$\delta^p - \delta^* = 11'\ 1''{\cdot}8 + 7''{\cdot}1 + 0''{\cdot}8 = +\ 11'\ 9''{\cdot}7$$

Der scheinbare Ort des Vergleichsternes war—

$$\text{app. } \alpha = 16^{h}\ 33^{m}\ 12^{s}{\cdot}54 \qquad \text{app. } \delta = -\ 9^\circ\ 18'\ 42''{\cdot}1$$

so dass sich ergab—

(216) 1881, Juli 20. $10^{h}\ 28^{m}\ 9^{s}$ M. Z. O'Gyalla:

$$\text{app. } \alpha^p = 16^{h}\ 35^{m}\ 17^{s}{\cdot}44 \qquad l.f.p. = 9{\cdot}2625$$
$$\text{app. } \delta^p = -\ 9^\circ\ 7'\ 32''{\cdot}4 \qquad l.f.p. = 0{\cdot}8627$$

Bei der Berechnung des Refractionseinflusses wird man übrigens wohl stets die eigene Bewegung des zu bestimmenden Objectes vernachlässigen und sich daher der gewöhnlichen Formeln—

$$d(\alpha' - \alpha) = k(\delta' - \delta)\,\frac{ctg\, n \cos(\mathrm{N} + 2\delta)}{\sin^2(\mathrm{N} + \delta)\cos\delta}$$

$$d(\delta' - \delta) = k(\delta' - \delta)\,\frac{1}{\sin^2(\mathrm{N} + \delta)}$$

bedienen dürfen.

Nicht nur bei diesem Mikrometer, sondern auch bei dem gewöhnlichen Kreismikrometer in der jetzt allgemein gebräuchlichen Form ergiebt ein Declinationsvergleich wenigstens zwei, beim Doppelringmikrometer aber sogar vier Resultate von ungleichem Werthe. Es rührt dieses daher, dass der Winkel ϕ unter dem man vom Mittelpunkte aus die Sehnen erblickt durch einen kleinen Fehler in der beobachteten Antrittszeit je mehr entstellt wird, je grösser er ist. Sei ds dieser Fehler der halben auf den Aequator reducirten Durchgangszeit, so erhält man durch Differentiation der Gleichung—

$$s^2 + y^2 = r^2,$$

$$\frac{dy}{ds} = -\frac{s}{y} = -tg\,\phi.$$

Zunächst geht aus dieser Gleichung hervor, dass für die Genauigkeit der Declinationsmessung der Radius des benutzten Ringes gar nicht in Frage kommt, dass dieselbe vielmehr nur von dem der beobachteten Sehne zugehörigen Centriwinkel abhängt.

Hat man ferner bei der Beobachtung desselben Objectes am inneren und äusseren Kreise die Sehnen $2s$ und $2s'$ gefunden und nimmt man an, dass die Fehler beider gleich gross sind, so hat man zwischen den Fehlern der daraus abgeleiteten Abstände gegen den Mittelpunkt die Beziehung—

$$\Delta : \Delta' = -s : -s'$$

Nach den Regeln der Wahrscheinlichkeitsrechnung ergiebt sich also die Wahrscheinlichkeit eben jene Fehler Δ und Δ' zu begehen durch—

$$\phi(\Delta) = \frac{k}{s\sqrt{\pi}} \cdot e^{-\frac{k^2\Delta^2}{s^2}}$$

$$\phi(\Delta') = \frac{k}{s'\sqrt{\pi}} \cdot e^{-\frac{k^2\Delta'^2}{s'^2}}$$

worin k eine Constante bedeutet, die nur von y abhängig sein kann. Der wahrscheinlichste Werth des unbekannten Abstandes ist hiernach jener, für welchen—

$$W = \frac{k^2}{ss'\pi} \cdot e^{-\frac{k^2\Delta^2}{s^2} - \frac{k^2\Delta'^2}{s'^2}}$$

ein Maximum, oder—

$$s'^2\Delta^2 + s^2\Delta'^2 = \text{Minimum}$$

wird. Leicht erkennt man, dass man allgemein bei der Beobachtung an m Ringen als Bedingungsgleichung für den wahrscheinlichsten Werth der Unbekannten erhält—

$$s^2_m\Delta^2 + s^2_{m-1}\Delta_1^2 + s^2_{m-2}\Delta_2^2 + \ldots\ldots + s^2\Delta^2_m = \text{Minimum}$$

Nennt man also x diesen wahrscheinlichsten Werth und $n, n_1, n_2, \ldots\ldots n_m$ die aus den einzelnen Ringen ermittelten Werthe, so hat man—

$$(s^2 + s_1^2 + s_2^2 + \ldots\ldots + s^2_m)x^2 - 2(s^2_m n + s^2_{m-1}n_1 + s^2_{m-2}n_2 + \ldots\ldots + s^2 n_m)x$$
$$+ (s^2_m n^2 + s^2_{m-1}n_1^2 + s^2_{m-2}n_2^2 + \ldots + s^2 n^2_m) = \text{Minimum},$$

oder nach der gebräuchlichen Bezeichnung—

$$[ss]x^2 - 2x\,[s^2{}_{m-\nu}n_\nu] + [s^2{}_{m-\nu}n^2{}_\nu] = \text{Minimum.}$$

Diese Bedingung wird aber erfüllt durch—

$$x\,[ss] - [s^2{}_{m-\nu}n_\nu] = 0,$$

$$x = \frac{[s^2{}_{m-\nu}n_\nu]}{[ss]}.$$

Gehen wir nun zur Untersuchung der in der Praxis vorkommenden Fälle über. Bei der Beobachtung an den beiden Rändern nur eines Ringes wird—

$$x = \frac{s_1{}^2n + s^2n_1}{s^2 + s_1{}^2} = \frac{\frac{n}{2}(s^2 + s_1{}^2) + \frac{n_1}{2}(s^2 + s_1{}^2)}{s^2 + s_1{}^2} - \frac{\frac{n}{2}(s^2 - s'^2) + \frac{n_1}{2}(s'^2 - s^2)}{s^2 + s'^2},$$

$$x = \tfrac{1}{2}(n + n_1) - \left(\frac{n - n_1}{2}\right)\frac{r^2 - r_1{}^2}{s^2 + s_1{}^2} = \tfrac{1}{2}(n + n_1) + \left(\frac{n - n_1}{2}\right)\frac{r_1{}^2 - r^2}{r_1{}^2 + r^2 - 2x^2}.$$

Der wahrscheinlichste Werth des Abstandes ergiebt sich also durch Anbringen der durch das zweite Glied dieser Formel ausgedrückten Correction an das arithmetische Mittel beider Messungen. Diese Correction findet man aber leicht, wenn man eine kleine Tafel berechnet die für verschiedene Werthe von x die zugehörigen Werthe des Coefficienten von $(n-n')$ giebt. Für einen der Ringe des hiesigen Positionsringmikrometers ergab sich unter Annahme von $r = 149''{\cdot}62$, $r_1 = 221''{\cdot}47$, folgende Tafel—

$x = 2'\ 29''{\cdot}0$	$f = 0{\cdot}986$	41	$x = 1'\ 50''{\cdot}0$	$f = 0{\cdot}564$	46
2 27·0	0·945	38	1 40·0	0·518	35
2 25·0	0·907	42	1 30·0	0·483	28
2 22·5	0·865	40	1 20·0	0·455	22
2 20·0	0·825	63	1 10·0	0·433	18
2 15·0	0·762	54	1 0·0	0·415	24
2 10·0	0·708	44	0 40·0	0·391	14
2 5·0	0·664	39	0 20·0	0·377	4
2 0·0	0·625		0 0·0	0·373	

Sind weiter r_1, r_2, r_3, r_4 die Radien eines Doppelringmikrometers, n_1, n_2, n_3, n_4 die an den verschiedenen Ringen aus den beobachteten Sehnen s_1, s_2, s_3, s_4 gefundenen Abstände, so ergiebt sich der wahrscheinlichste Werth dieses Abstandes durch—

$$x = \frac{n_1s_4{}^2 + n_2s_3{}^2 + n_3s_2{}^2 + n_4s_1{}^2}{s_1{}^2 + s_2{}^2 + s_3{}^2 + s_4{}^2}$$

$$= \tfrac{1}{4}(n_1 + n_2 + n_3 + n_4) + \frac{n_4 + n_3 - n_2 - n_1}{4} \cdot \frac{s_1{}^2 + s_2{}^2 - s_3{}^2 - s_4{}^2}{s_1{}^2 + s_2{}^2 + s_3{}^2 + s_4{}^2}$$

$$+ \frac{n_4 - n_3}{2} \cdot \frac{s^2 - s_2{}^2}{s_1{}^2 + s_2{}^2 + s_3{}^2 + s_4{}^2} + \frac{n_2 - n_1}{2} \cdot \frac{s_3{}^2 - s_4{}^2}{s_1{}^2 + s_2{}^2 + s_3{}^2 + s_4{}^2}$$

$$= \tfrac{1}{4}(n_1 + n_2 + n_3 + n_4) + \frac{n_4 + n_3 - n_2 - n_1}{4} \cdot \frac{r_1{}^2 + r_2{}^2 - r_3{}^2 - r_4{}^2}{r_1{}^2 + r_2{}^2 + r_3{}^2 + r_4{}^2 - 4x^2}$$

$$+ \frac{n_4 - n_3}{2} \cdot \frac{r_1{}^2 - r_2{}^2}{r_1{}^2 + r_2{}^2 + r_3{}^2 + r_4{}^2 - 4x^2} + \frac{n_2 - n_1}{2} \cdot \frac{r_3{}^2 - r_4{}^2}{r_1{}^2 + r_2{}^2 + r_3{}^2 + r_4{}^2 - 4x^2}$$

Auch hier wird man die Coefficienten der drei Correctionsglieder in eine Tafel mit dem Argumente x bringen und sie dann leicht berücksichtigen können.

Um ein Urtheil über die Genauigkeit der Messungen mittels des Kreismikrometers zu erlangen, schlug ich folgenden Weg ein. Ich leitete für die auf pp. 94, 95 dieser Zeitschrift mitgetheilten Planetenbeobachtungen die bei den einzelnen Messungen begangenen Fehler ab, reducirte dieselben sämmtlich auf ein und denselben Werth des Winkels ϕ und fand dadurch den mittleren Fehler ε des einzelnen aus einer dem Winkel ϕ zugehörigen Sehne abgeleitetem Resultate. Es ergab sich aus 30 Messungen an den inneren Kreisen für $\phi = 15^\circ$—

$$\varepsilon_{15} = \pm 1''\cdot03744$$

und aus 53 Beobachtungen an den äusseren Ringen: $\varepsilon_{15} = \pm 1\cdot03301$; hiernach wurde angenommen—

$$\varepsilon_{15} = \pm 1''\cdot0346.$$

Nach bekannten Formeln ergab sich hieraus der Werth der Constanten—

$$k = -\,tg\,\phi\,ds$$

in der Formel—

$$\phi(\Delta) = \frac{k}{\sqrt{\pi}} \cdot e^{-k^2\Delta^2}$$

zu—

$$k = 0\cdot68346$$

entsprechend dem Werthe—

$$ds = 2''\cdot551 = 0^{s}\cdot170$$

Andererseits fand ich aus 300 Antrittsbeobachtungen an einem Fadennetze den mittleren Fehler der einzelnen Schätzung—

$$\varepsilon = 0^{s}\cdot065.$$

Beide stimmen, da *ds* die Summe zweier Fehler der letzteren Art ist, hinreichend überein um das Mittel—

$$ds = 0^{s}\cdot150$$

als der Wahrheit sehr nahe kommend erscheinen zu lassen.

Diesen Werth benutzte ich um zu ermitteln, wie viele Beobachtungen der vorgeschriebenen Art genügen, um den wahrscheinlichen Fehler des aus ihnen abgeleiteten Declinationsabstandes eine vorgeschriebene Grösse zu geben. Es ergab sich, dass erst bei 49 Beobachtungen dieser Fehler 0''·1 wird; bei der von mir in der Regel benutzten Anzahl von 8 Beobachtungen stellt er sich auf ± 0''·25. Dabei ist nach den der ganzen Rechnung zu Grunde liegenden Beobachtungen vorausgesetzt, dass die eine Hälfte der Beobachtungen in der nördlichen, die andere in der südlichen Hälfte der Ringe angestellt werde, wodurch verschiedene Fehlerquellen umgangen werden.

O'Gyalla, 1881, August.

METEOR STREAMS.

By W. F. DENNING.

The following list comprises a few of the most active meteor showers observed at Bristol since 1876. The positions have been selected of such showers as exhibited a well-defined radiant point and were confined in their most active display to a comparatively short period. The epoch of the streams as given in the table must however not be supposed to include the entire period of their visible sustenance, for in many cases the duration is prolonged for several weeks beyond what is specified, sometimes feebly, but occasionally with marked activity. Take the cases of the July Andromedes (No. 6), Triangulids (No. 8), and Cassiopeids (No. 9), which give from apparently the same radiant points a series of showers extending over the ensuing three months. There is a radiant in the eastern region of Aries (Nos. 15, 29, 33 and 36) which becomes successively active during the four months August to November, and there are other well-defined instances in which it seems impossible to adopt a short period. I have seen a display from near β Tauri (No. 26) at the end of August and again in September, October and November, and it is remarkable that the radiant seems to retain a fixed position. Another series of showers apparently from the same radiant is represented by Nos. 8 and 21, the diverging focus being 2° north of β Trianguli. The following are a few well determined positions of these radiants:

Showers near β Tauri.

Aug. 6–12,	74°	+ 33°
„ 27,	75	+ 33
Sept. 14–25,	76	+ 32
Oct. 2–18,	77	+ 31
„ 12–21,	78	+ 33
„ 13,	77	+ 30*
„ 14–15,	76	+ 33
Oct. 28–Nov. 13,	77	+ 32

* Observed by Tupman.

Showers near β Trianguli.

July 26–Aug. 1,	28°	+ 36°
„ 29,	30	+ 37
„ 30,	32	+ 35†
Aug. 3–16,	30	+ 36
Sept. 15–25,	30	+ 36
„ 23,	28	+ 35†
Oct. 8,	30	+ 36

† Observed by Zezioli.

As to the shower near β Tauri I am certain of the exact position of its radiant point in September, October and November, but in August only a few of its meteors have been seen, so that I am less confident. Tupman recorded a shower at 70° + 31°, Aug. 29, 1870 and Schmidt gives 70° + 32° (September) and 71° + 31°, October 10–27. This is 2° south of ι Aurigæ and 5° west of the true position of the shower centre. It is very important that this stream be re-observed in August and its radiant accurately derived. If the position is at 77° + 32° in exact conformity with the place of the shower as I have repeatedly observed it during the three ensuing months, it will be at least remarkable and may direct attention to other instances of long duration and the necessity of a close investigation of the whole subject.

Whether such apparently identical radiants are in any way physically connected must be discussed on the basis of renewed observation. Meteoric systems moving in parabolic or elliptic orbits can of course only appear to diverge from the same radiants for a very short period. It is obvious that we require a large amount of additional labour directed to the solution of this complex problem. To select a number of the more prominent streams such as those which have been actively visible during the last few years may possibly offer some inducement to observers to effect their re-observation and attempt to determine their periods.

Principal Meteor Streams observed at Bristol, 1876-79.

No.	Year and Date 1880 +.	Radiant Point.		No. of Meteors.	Name of Stream or Star near Radiant; Notes.
		α	δ		
1	79-80, Jan. 2,	229°	+ 53°	33	Quadrans. Slowish trained meteors.
2	77, Jan. 14 and 17,	295	+ 33	9	χ Cygni. Bright slow meteors with trains.
3	77, Feb. 20,	181	+ 34	8	Coma Berenices. Very swift white meteors.
4	77, March 10,	247	+ 52	10	τ Herculis. Swift short meteors.
5	78-79, April 21 and 22,	272	+ 33	21	Lyrids. Max. April 20. Swift meteors.
6	77, July 6-17,	4	+ 35	21	ρ Andromedæ. Very swift streak-bearing meteors. There are a series of active showers from this point in July and August.
	78, July 25-31,	6	+ 37	19	
	77-78, Aug. 3-16,	10	+ 38	16	
7	78, July 25-26,	332	+ 37	11	π Pegasi. Brilliant slow meteors with long paths.
8	77-79, July 26-Aug. 4,	30	+ 36	24	β Trianguli. Swift streak-leaving meteors.
9	78, July 21-Aug. 1,	11	+ 50	26	ζ Cassiopeiæ. Very swift streak-leaving meteors.
10	78-79, July 28-31,	341	— 13	73	δ Aquarii. Slow trained meteors with long paths.
11	78-79, July 30-Aug. 1,	32	+ 53	76	χ Persei. Swift short meteors with streaks.
12	78, July 31-Aug. 1,	332	+ 50	14	Lacertids. Swift meteors.
13	78, July 30-Aug. 1,	12	+ 70	16	ψ Cassiopeiæ. Small meteors not very swift.
14	78, August 1-2,	291	+ 70	14	δ Draconis. Swift short meteors.
15	77-81, Aug. 8-11,	44	+ 25	20	ε Arietis. Swift bright meteors with long paths.
16	76-81, Aug. 1-13,	43	+ 57	784	Perseids. Max. Aug. 10. Meteors very swift with streaks.
17	77, Aug. 10-12,	70	+ 65	10	c Camelopardali. Swift streak-leaving meteors.
18	77, Aug. 12-16,	31	+ 18	11	α Arietis. Meteors very swift with bright streaks.
19	79, Aug. 21-25,	291	+ 60	52	ο Draconis. Slow trained meteors rather bright.
20	77-79, Sep. 6-15,	61	+ 36	25	ε Persei. Fine meteors with streaks.
21	79, Sep. 15-25,	30	+ 36	16	β Trianguli (= No. 8). Meteors not very swift.
22	79, Sep. 21,	31	+ 19	10	α Arietis (= No. 18). Meteors slow and trained.
23	79, Sep. 14-25,	99	+ 43	15	Lyncids. Very swift meteors leaving streaks.
24	77, Oct. 2,	225	+ 52	7	Quadrans. Very large slow-moving meteors.
25	77, Oct. 3-5,	133	+ 79	11	Camelopardalus. Very swift meteors with streaks.

No.	Year and Date 1880 +.	Radiant Point.		No. of Meteors.	Name of Stream or Star near Radiant; Notes.
		α	δ		
26	76–77, Sep. 15–25 and Oct. 8–15.	77°	+ 32°	23	β Tauri. Meteors swift and streak-leaving.
27	77–79, Sep.–Oct., . .	81	+ 55	45	δ Aurigæ. Meteors swift and streak-leaving.
28	77–79, Oct. 2–19, . .	104	+ 12	28	β Canis Minoris. Meteors very swift with streaks and long paths.
29	76–77, Oct. 8 and 14–15, .	47	+ 26	20	ε Arietis. Swift meteors.
30	79, Oct. 14–15, . .	31	+ 9	29	ξ Arietis. Slow faint meteors with trains.
31	79, Oct. 15, . .	106	+ 23	11	ζ Geminorum. Very swift long meteors.
32	76–79, Oct. 15–25, . .	91	+ 16	113	Orionids. Swift short meteors with streaks.
33	77, Oct. 29–Nov. 1, .	43	+ 22	13	ε Arietis. Large meteors slow and trained like Taurids.
34	77–79, Nov. 13, . .	148	+ 23	23	Leonids. Meteors very swift with streaks.
35	77–79, Nov. 12–14, 19–20 and 27.	61	+ 22	43	ε Tauri. Large slow-moving meteors with trains.
36	79, Nov. 12–14, . .	46	+ 21	19	ε Arietis. Slow trained meteors (see Nos. 15, 29, and 33.)
37	76–80, Nov. 25–Dec. 6, .	80	+ 23	31	ζ Tauri. Max. Dec. 6. Brilliant slow meteors.
38	76, Nov. 25–28, . .	155	+ 36	21	Leo Minor. Very swift streak-leaving meteors.
39	76, Nov. 25–28, . .	208	+ 43	13	η Ursæ · Majoris. Swift small meteors without streaks.
40	76–80, Dec. 8–12, . .	106	+ 32	70	Geminids. Quick short meteors.

RECENT LITERATURE.

"*Visite à divers Observatoires d'Europe. Notes de voyage par M. J. Perrotin, Directeur de l'Observatoire de Nice*" (Paris, Gauthier-Villars, 1881, 150 pp. 8vo). This book contains short but concise descriptions of the principal instruments in the observatories in central and northern Europe visited by M. Perrotin in the summer and autumn of 1880. The Author dwells particularly on interesting and novel constructions, and his book will be found an invaluable guide to anyone wishing to become acquainted with the many modern improvements in astronomical instruments. We shall extract a few particulars from M. Perrotin's descriptions.

The new Meridian circles made by Messrs. Repsold for the observatories at Strassburg, Bonn and Brussels, have each two circles, one divided all round to two minutes, the other only divided to whole degrees, but having four spaces of 60′, 90° apart, divided to two minutes. In this way the complete study of the division errors becomes less troublesome, being limited to a small number of lines, and as the circle is movable round the axis, the observer can always arrange the observation of a certain star so that the finely divided parts are opposite the four microscopes, while one of the degree lines is used in observing the Nadir. Messrs. Repsold have also constructed an altazimuth for the Strassburg Observatory. In this instrument the telescope (with an aperture of five inches and a focal length of five feet) is placed at the extremity of the horizontal axis. The two circles are divided to 2′, the horizontal one is read by four microscopes and the vertical one by two. A level attached to the tube facilitates observations of equal altitudes. The position of the telescope made it necessary for the dome, under which the altazimuth is placed, to be formed of two independent halves which roll on horizontal and parallel rails and can be separated from one another, producing an opening 2½ meters wide.

The new Vienna Observatory is fully described, including the three domes made by Mr. Grubb, whose "live-ring" principle continues to prove superior to any other contrivance for rotating heavy domes. The 27-inch refractor was still in Mr. Grubb's workshop when M. Perrotin visited the latter; it is described in the chapter "Dublin." At Pulkowa the Author found the 15-inch refractor dismounted, a new mounting being in course of construction by Messrs. Repsold, who are also engaged in making the mounting for the 30-inch Clark Refractor. The latter is to have a focal length of about 43 feet, and the lenses of the object-glass are to be about six inches apart.

From M. Perrotin's concluding chapter we extract the following remarks which will be read with interest:—

"The preceding descriptions of various equatoreals show that English and German makers pay much attention to the comfort of the observer; the arrangements for the slow motions and the reading of the circles are often very ingenious, but they complicate the instrument and may in some cases injure its stability. The tubes of meridian instruments are of brass, but it does not seem proved that they are more homogeneous than the French cast-iron tubes. On some meridian circles, such as those of Pistor and Martins, the hooks which lift the greater part of the weight of the instrument off the pivots, catch the axis too near the central cube and may produce torsion in the axis. It may also be dangerous to let the levers which carry these hooks and the counterpoises be supported on metal barrels which also carry the Y's and the microscopes, as is the case in several of Repsold's instruments. Finally, might it not be better to let the clamp act on one of the circles than to let it pinch the axis? Without pretending that the French instruments are perfect, it is certain that they are simpler; the Bischoffsheim meridian circle of the Paris Observatory, constructed by M. Eichens, and the new equatoreal of the Toulouse Observatory, made by MM. Brünner, can compare favourably with the instruments of other makers." Lastly the Author commends the system of practically training astronomical students, which has proved so successful in many places on the continent and which has lately been introduced at the Paris Observatory.

"*Recherches sur la Verticale par M. Antoine d' Abbadie*" (Annales de la Société scientifique de Bruxelles, 1881, 15 pp. 8vo with a plate). This paper gives an account of the "Nadirane" or instrument for measuring changes in the direction of the plumb-line, constructed by M. d'Abbadie and already described in the

Comptes Rendus of the French Association for 1872 (see also "The Observatory" Vol. II. p. 52). To illustrate the observed changes, the Author gives the details of a series of observations made daily at 6 A.M. from Sept. 8, 1879 to Sept. 7, 1880. During this period the vertical line varied to the extent of 4″·03 in the direction of the meridian, and 2″·7 in the direction East and West. The observations are sufficient to prove the necessity of taking into account the momentary position of the vertical during each observation of a series of determinations of latitude or absolute declinations. That small deviations also exist in the southern hemisphere was proved by M. Bouquet de la Grye at Campbell Island in 1874 with an instrument totally different from M. d'Abbadie's.

"*Quelques Resultats déduits de la Statistique Solaire, par R. Wolf, Premier Article*" (Mem. della Soc. degli Spettr. Ital. 1881, 15 pp.). In this paper are given in two tables the relative numbers and the "compensated relative numbers" from 1749 to 1880, separately for each month and the annual means. The second of these tables (up to 1876) had already been published in the Memoirs of the R. Astron. Society Vol. 43, p. 205 & seq. Taking the differences p between each two consecutive epochs of Maximum or Minimum of Sun Spots from 1610 to 1879, Professor Wolf finds 47 values of p and computes for $n = 1, 2, 3 \ldots 47$ the successive values of—

$$P = \frac{1}{n}\Sigma_1^n p.$$

The series thus formed shows the different values for the mean length of the period which might from time to time have been found since the discovery of Sun Spots by using the present methods. Thus Galileo and Scheiner would have found a period of eight or nine years, Picard in 1675 would have found 11·470 years, Christian Horrebow (who first suspected the periodicity) would have found 10·920 years in 1778 &c. Professor Wolf finds the following normal epochs :—

Min. = 1755·364 + A · 11·132 Max. = 1760·342 + A · 11·132

"*Ueber den Doppelstern Σ 60 = η Cassiopejæ. Von Ludwig Struve*" (Mélanges mathém. et astron. T. V, 34 pp. 8vo). The orbit of this double star has from time to time been determined by several computers, who have made use of all the existing measures made since 1782. By his father's advice the Author of the present paper has however only founded his orbit on the observations made at Dorpat (1831–37) and Pulkova (1841–79) and on one observation made by Bessel in 1830. Having corrected these measures in accordance with the formulæ given in Vol. IX of the "Observations de Poulkova," M. Struve formed fourteen normal places and found by using Sir J. Herschel's second method the following elements—

$\Omega = 45^\circ \; 3'$ Equinox 1850·0
$i = 56 \; 22$
$\lambda = 238 \; 17$
$e = 0{\cdot}6296$
$P = 148^y{\cdot}90$
$T = 1905{\cdot}02$
$a = 8''{\cdot}786$

The comparison of this orbit with the observations shows a very satisfactory agreement. The orbit is next compared with the corrected measures of Dawes, Dembowski and Dunér. The agreement is here less satisfactory, the observed distances all (except one) being greater than the computed ones. Whatever be the cause of this discrepancy, the elements agree exceedingly well with the means of the distances of O. Struve, Dembowski and Dunér, the remaining differences since 1870 being—

	$\rho_o - \rho_c$
O. Struve	$- 0''{\cdot}242$
Dembowski	$+ 0{\cdot}104$
Dunér	$+ 0{\cdot}146$

The Position Angles observed during the last twenty-five years by these three observers are all smaller than the computed ones, which appears to prove that the period of revolution found by M. L. Struve is a little too small. The elements were however considered sufficiently accurate to determine the relative masses and the place of the centre of gravity of the system by means of them and the irregular proper motion of the principal star. To the places of the latter used by Auwers in preparing the Fundamental Catalogue for 1875, the Author has added positions deduced from a very able discussion of observations by Piazzi, Groombridge, W. Struve and Argelander. The ten positions for 1875 thus derived furnish ten pairs of equations of condition, from which the R.A. and Declination and Proper Motion of the Centre of Gravity are found. That the proper motion is irregular is seen from the fact that the place of η Cassiopeiæ from Auwers' Catalogue combined with a uniform motion makes the sums of the squares of the residuals come out considerably greater than the data found by the above process do. The resulting ratio of the mass of the companion to the sum of the two masses is—

$$\frac{m'}{m + m'} = 0{\cdot}212 \pm 0{\cdot}018$$

The parallax of η Cassiopeiæ found by O. Struve ($0''{\cdot}154$) combined with the elements deduced by his son gives $m + m' = 8{\cdot}33$, the mass of the Sun being unity, and accordingly $m = 6{\cdot}57$ and $m' = 1{\cdot}76$.

It is deserving of notice that Professor Schjellerup's comparison between the Right Ascension of Hipparchus for η Cassiopeiæ and the R.A. for B.C. 140 deduced with and without the secular proper motion of $+ 206''{\cdot}5$ (see above, p. 39) seems to indicate that η Cassiopeiæ formerly moved much more slowly than at present.

"*Note sur l'analyse de la lumière de la comète de* (*b*) 1881, *par Ch. Fievez*" (Bulletin de l'Acad. R. de Belgique, 3^{me} Série T. I, 3 pp.). With a polariscope attached to the new 15-inch Refractor, at Brussels, the light of the Nucleus was distinctly seen to be polarized, while the polarization of the tail was very feeble. These observations were repeated on several evenings; the polarization of the sky was scarcely perceptible. In the spectrum of the comet four bands were seen and measured; they were all well defined towards the red end and faded away gradually towards the violet. The wave-lengths were 5160, 4780, 5620 ± and 4200 ±. As the comet receded from the Sun, the edges of the bands towards the red became more sharply defined. The continuous spectrum of the Nucleus was at first very brilliant and the spectral bands of the Coma were not visible in it, but as the continuous spectrum grew fainter, the bands were seen through it. No dark lines could be detected.

THE MEETING OF THE "ASTRONOMISCHE GESELLSCHAFT" AT STRASSBURG, SEPTEMBER 22–24, 1881.

The meeting, under the presidency of Professor Auwers, was welcomed in the new Observatory by His Excellency Herr Hoffman, Secretary of State for Alsace-Lorraine. In a few words he pointed out the desirability of widening to the utmost the limits set to astronomical discovery by the relative imperfection of instruments, indicating how the German Government had endeavoured to widen these limits as far as practicable in the magnificent building in which they were assembled.

The Society consists of 306 members inclusive of 34 new ones definitively elected at the meeting. Sketching the history of the Society during the last two years the President explained that on the retirement of Sir George Airy after filling the post of Astronomer Royal for 46 years, the Council felt it their bounden duty to offer their congratulations on the rich harvest that had rewarded his labours, coupled with the hope that his life might long be spared to prosecute the Lunar and other investigations to which he wished to devote himself more fully during the remainder of his life.

The usual communications were made by the office bearers on the state of the Society's funds and publications. The approaching publication of Ecliptical Tables by Professor Oppolzer was announced. The observations of northern zones being now almost completed, steps had been taken to secure the observations of the belt − 2° to − 23°, for which a special catalogue of 303 stars had been selected by M. O. Struve and Professors Schönfeld and Bakhuyzen acting as a committee. The observatories at Leyden and the Cape of Good Hope had undertaken to furnish 16 observations of each of these stars, taken with every known precaution as to reversal of the instrument, interchange of object-glass and eye-piece, &c. In addition, two sets of stars specially chosen to determine the constants of refraction were to be observed 32 times at both observatories. 500 observations of these classes had already been made at Leyden. These star-places were to be assimilated as closely as possible to the 539 stars of the Society's list; Ephemerides of 450 of these stars have been incorporated in the Berliner Jahrbuch from 1883. The observatories at Naples, Melbourne and probably also that of Sydney will co-operate in the above observations.

An animated discussion arose respecting the recent arrangement between the Prussian Minister of Education, the Editor of the "Astronomische Nachrichten" and the Council of the Society, by which the Council pledged themselves as far as possible to make the Astron. Nachrichten the chief astronomical journal. The terms of this agreement seeming to implicate the individual members of the Society, an objection was made in the first instance by Professor Peters of Hamilton College as to the obvious injustice done to foreign members of the Society. Dr. Copeland pointed out the dangers to science from over-interference on the part of any government, referring to the pregnant words of Sir John Lubbock at the close of his address to the British Association assembled at York. Professor Auwers explained that the obligations entered on were only binding on the members of the Council, and that they had been forced to take their present line of action by the fact that the copyright of the Astr. Nachrichten had been declared to be the property of the Prussian Government, which, apart from having made certain compensations to the heirs of the late Editor, considered itself the successor to certain rights possessed by the former Danish Government of the Duchy of Holstein. As it seemed certain that the Prussian Government on its own account would have continued the publication of the journal, the Council took their recent course from a desire to see so invaluable a publication continued in the best possible manner. This arrangement met with the all but unanimous assent of the meeting.

Owing to the lamented death of the late Professor Bruhns no report on cometary astronomy was presented, a quadrennial report being purposed for the next meeting.

We now proceed to give as accurate and complete an account of the principal communications made to the meeting as it was possible to obtain without the aid of a short-hand writer.

Professor Folie of Liege presented specimens of forthcoming tables of precession and nutation for 1875 on the basis of Struve's constants.

Photographs were next exhibited of very successful attempts made by Herr Meydenbauer to imitate Lunar Formations by strewing dextrine on a layer of flour.

Dr. Schur of Strassburg read abstracts from a paper on the mass of Jupiter. An investigation of this kind was the more desirable as a reform of the tables of the satellites has become imperatively necessary. Dr. Schur made 176 complete measures of distance and 154 of position-angle of the satellites during the years 1874–80 with a small heliometer. The result was 1047·232 for the ratio between the Sun's mass and that of Jupiter, with a mean error of ± 0·365. Bessel had deduced 1047·879 ± 0·25 from 161 observations, but a new reduction of his measures, neglecting the periodic correction, as to the reliability of which some doubt existed, and increasing the temperature correction, gave 1048·629 ± 0·198.

The lesser mean error of Bessel's result is partly due to the greater accuracy of his observations, which were made with a larger instrument and also to his having chiefly observed the third and fourth satellites. Observations by Triesnecker (1794-95) and Santini had been discussed anew by Dr. Schur and gave 1048·55 ± 1·45 and 1051·09 ± 2·24, and eventually Bessel's and the Author's measures combined gave the final result 1048·311 with a mean error of ± 0·174. When Jupiter was far from opposition the effect of the phase was very appreciable (particularly in 1876) as the character of the limb became so changed as to make the observer set the satellite too far into the planet's limb. Professor Safarik of Prague confirmed this appearance, referring to Mädler's well known "Beiträge" as mentioning the phenomenon. Professor Gyldén expressed some doubts as to the sufficient accuracy of some of the generally accepted formulæ

M. O. Struve alluding to a paper by his son Ludwig Struve on η Cassiopeiæ (see above pp. 198-199) pointed out the constant differences amounting to 0″·4 between the distance as measured by Dembowski, Dunér and himself, a difference far greater than usually occurs in the case of other stars. The rejection of the correction derived from measures of artificial stars somewhat improved matters, but the speaker seemed inclined to attribute the discrepancy to a correction dependent on the four-fold angle of position as well as to the frequent observation of the star under bad atmospheric conditions, which almost invariably tended to lessen the interval by 0″·1 to 0″·15. In reply to a question by Prof. Oudemans the speaker stated that Vol. X. of the Pulkova Observations will contain instances in which the necessity of periodic corrections had been tested by observing double stars right round the pole.

M. Niesten of Brussels exhibited some beautiful drawings (made with an aperture of 15 inches) of the Nucleus and jets of comets 1881 II. and III. (as it is now decided to name comets *b* and *c*) and also showed some drawings of the lunar surface made with a 6-inch refractor.

Professor Schönfeld was able to inform the meeting that his Durchmusterung of the heavens between − 2° and − 23° was very nearly finished, some 356,000 observations having been accumulated. The revisions had been so extensive and thorough that it was understood that only one star not fainter than 9·3 mag. had escaped a twofold observation. The chart of Hora XIII. drawn by Herr Scheiner was exhibited; it contains 4,233 stars exclusive of those in the overlap. It is confidently believed that the whole work will be finished by the next meeting of the Society in 1883.

Professor Safarik distributed lithographed copies of a full-length portrait of Tycho Brahe which existed in a presentation copy of the *Progymnasmata* now in Prague.

More or less full particulars were next communicated respecting the progress made during the last two years in the exact observation of all the stars down to the ninth magnitude between + 80° and − 2° as also of all fainter stars within these limits occurring in Bessel's and Argelander's zones. The observations to be made at Kasan (80° to 75° Decl.), Dorpat (75° to 70°), Christiania (70° to 65°), Helsingfors-Gotha (65° to 55°), Harvard College (55° to 50°) and Bonn (50° to 40°) have all been very nearly finished and the reductions are far advanced. In Bonn a mean difference has been found between observations in reversed positions, amounting to 1″·28, but this is in a great measure covered by the constant difference of 0″·96 between East and West. Three wire netting screens have been used to reduce the apparent brightness of stars by about two magnitudes during part of their transit through the field. The result is :—Faint − Bright = − 0ˢ·021, the sign being contrary to that found at Leyden. In Lund (40° to 35°) the observations were commenced in 1878 and will probably be finished this winter; the reductions are progressing well. The Leyden zone (35° to 30°) was finished several years ago and the final places are being rapidly deduced. At Cambridge (30° to 25°) the reductions are also far advanced. Of the two Berlin zones (25° to 20°) and (20° to 15°) the latter was finished some years ago by Professor Auwers with the 4-inch transit circle. The thin, ventilated walls of the new meridian room have secured so great a uniformity of temperature, that a power of 230 could almost always be used on the 6-inch transit circle for the other zone. At Leipzig the zone 15° to 10° is finished and the zone 10° to 5° progressing. The zone 5° to 1° is being observed at Albany, where the work has been much affected by the looseness of the object-glass, which had been taken out to be repolished by Clark.

The zone between + 1° and − 2° is confided to the Nicolajeff Observatory. M. Struve stated that a good deal had been done already, and that rapid progress could now be guaranteed, as the Observatory at Nicolajeff had, to a certain extent, been affiliated to the Central Observatory at Pulkova.

Professor Gyldén gave the outlines of a method by which the outstanding inaccuracies in astronomical computations, due to inadequate convergence of series, may be lessened.

Professor C. H. F. Peters, in the name of Professor Draper, presented photographs of Comet *b* 1881, and of the nebula in Orion. Prof. Peters also exhibited a photo-lithograph of one of his ecliptic maps constructed in the search for minor planets. The scale is four times that of the Bonn maps or about the size of Chacornac's. In all about 30 maps will be published, some ten or twelve of which will appear in the course of the winter. The method chosen for their reproduction (the expense of which will be borne by Prof. Peters) ensures the greatest possible accuracy.

Professor Peters also showed how Kepler's equation—

$$E = M + e \sin E$$

could be solved by the mere aid of ordinary logarithmic tables more rapidly than by using even the most extensive auxiliary tables. For a five-place computation $\log e$ in minutes of arc was written down; then with any approximate value of E

(say $E = M$) *log e sin E* was mentally computed and *e sin E* added to *M*, thus giving a closer approximation to *E*. In practice one finger of the left hand is inserted in the table at *log sin E*, while another finger retains the place of *e sin E* in the logarithms of numbers. None who had the pleasure of attending the meeting will forget the simplicity and ease which the method assumed in the hands of the veteran astronomer.

M. Niesten on behalf of M. Houzeau exhibited plans of the new Observatory which is to be erected about a league south of Brussels. All the observatory buildings although sufficiently far from each other, are connected by covered corridors (as in the case of the three buildings at Strassburg). It is proposed to erect no less than ten detached residences for the assistants, each in its own grounds. A considerable rise in the ground throws the chief observatory buildings considerably above the dwelling-houses.

M. Folie described the observatory now in course of construction at Liege.

Dr. Backlund gave some account of Encke's comet and stated that a change in the mean anomaly would fairly meet the difference between the observed and predicted place. The agreement would have been better if Asten's correction of $0''\cdot104$ in the mean motion had been omitted; indeed, a correction in the opposite direction is required.

A universal instrument by Eugen Hartmann, likely to meet the wants of travellers, was exhibited. The telescope forms the axis, a large right-angled prism being in front of the object-glass.

Professor Krüger exhibited an educational apparatus by a Swedish maker for showing the changes of the seasons.

A circular was received from Reggio-Emilia, the birth place of Secchi, where it is proposed to erect a memorial refractor of not less than 70 centimeters aperture: (a similar movement led to the foundation of the Arcetri Observatory in memory of Galileo).

M. Janssen, who was most cordially welcomed by the meeting, exhibited a fine photograph of Schaeberle's comet, showing the principal jets of the tail with great distinctness. M. Janssen also explained how a series of such photographs taken with uniform exposures when a comet was at various distances from the Sun would decide the proportions of reflected and proper light. Particulars were also given and photographs exhibited, illustrative of photographic photometry as applied to compare the radiant power of the Sun and Stars (see Comptes Rendus, 4 April 1881).

Dr. Copeland exhibited chronograph sheets showing the practically perfect action of the Dun Echt driving clock during a period of nearly six hours. This clock drives any or all of four chronograph barrels as also the 15-inch refractor. Dr. Copeland also explained the principle of the *Science Observer Code* (see above p. 179), and illustrated it by a telegram of 22 words received from Boston about a variable star (see Dun Echt Circular No. 31, p. 206).

As a further chance illustration of the imperfections of the old system a contradictory telegram about a new comet (Barnard) was received from the Vienna Academy. The meeting generally, and Professor Förster in particular, seemed to be of opinion that the *Science Observer Code* successfully disposed of the chief difficulties of international telegraphy. A communication from Prof. Newcomb was then presented, in which the use of another code-book and consequent minor changes were suggested. Messrs. Peters, Schiaparelli, Förster, Weiss, Krüger and Copeland were appointed to discuss the subject and decide on the course to be adopted. The committee decided for the present to retain the Smithsonian system with five European centres, the limits of whose districts were to be defined. It was especially recommended that the telegrams should pass through the hands of one of the Washington astronomers. In the mean time it seemed desirable that Messrs. Chandler and Ritchie should continue to test their code in conjunction with the Dun Echt Observatory. Doubtless the chief reason for retaining the old and imperfect code was a feeling of consideration for the Smithsonian Institution, which has so long used its best endeavours in the service of Astronomy.

M. Vieweg explained the advantages to be gained by the combination of one of Christie's half-prism spectroscopes with a Rutherfurd grating. The space between b_1 and b_2 occupied 1° 30′ in the field of a telescope of 22 centimeters focus.

Professor Peters proposed a list of equatoreal stars to be observed for magnitude in both hemispheres to secure uniformity in the estimations.

Dr. Feddersen requested the co-operation of the members in the continuation of Poggendorff's Biographical Dictionary, on which he is engaged.

Herr Hartwig proposed to mark the variable stars by two Roman capitals (R.R., R.S., &c.), of which a sufficient number could always be found.

Professor Bakhuyzen presented a copy of Schroeter's "Areographische Fragmente," which have just been printed by the University of Leyden. Fourteen of Schroeter's original copper-plates have been utilized and two missing ones have been engraved in Holland. The work possesses a special interest from the fact that Schroeter inclined to the belief that the markings on Mars were variable.

Dr. Kobold presented Vols. II. and III. of the O'Gyalla publications. Dr. Meyer exhibited a highly interesting arrangement for chronographing the *audible* beats of a clock by means of the telephone. Dr. Hugo Schröder exhibited various optical appliances, but owing to the press of business, these and other demonstrations were relegated to spare hours, which were difficult to secure.

The members present (about fifty) were much indebted to the courtesy shown them by the Secretary of State, who entertained the whole meeting at a Soirée, by the Burgomaster and by the representatives of the University. Prof. Winnecke, and Drs. Schur and Hartwig were untiring in their efforts to exhibit and explain the many novel appliances of their magnificent observatory. The next meeting will be held in Vienna, in 1883.

DUN ECHT CIRCULAR, No. 30.

The Astronomer Royal kindly telegraphs :—

"Two rather contradictory telegrams have been received from the Smithsonian Institution : September 21, 10 o'clock, A.M., Mr. Barnard, Nashville, Tennessee, announces bright Comet, seven forty-six Ascension, thirteen twenty-eight north. Daily motion three degrees north-east.

Second telegram. September 21, 3 o'clock, P.M., Comet in thirteen twenty-eight north three forty-seven. Daily motion three degrees north-east."

Lord Crawford's Observatory,
Dun Echt, 1881, September 22.

DUN ECHT CIRCULAR, No. 31.

The following is the translation of a message from the Science Observer, Boston, received on Sept. 22, by Dr. Copeland, while in Strassburg. The information was sent in accordance with the "Science Observer" code in twenty-two words.

A probably variable star was discovered by Professor Pickering, on Sept. 13, red; spectrum banded. The epoch and period are not known. The magnitude is as follows :—

September 12 = $8^{m}\cdot 9$ September 17 = 8 ·6
South preceding 1 $50^{s}\cdot 5$ and 10′ 18″ of D. M. + 72°, 735.

The place on September 14 was :—

$$\alpha = 16^{h}\ 31^{m}\ 32^{s} \qquad \delta = +\ 72^{\circ}\ 32'$$

Elements and Ephemeris of Comet *e* (Barnard), computed by S. C. Chandler, Jr., from somewhat unsatisfactory observations, on September 20, 21, and 25, and transmitted as usual by the "Science Observer" code.

Elements.

$$T = 1881,\ \text{September } 15\cdot 01 \text{ Greenwich M. T.}$$

$$\left.\begin{aligned}\pi &= 271^{\circ}\ 22'\\ \text{☊} &= 260\ \ 43\\ i &= 107\ \ 27\end{aligned}\right\}\text{Mean Equinox 1881.}$$

$$\log q = 9\cdot 70535$$

Ephemeris for Washington Midnight.

1881	α			δ		Brightness.
Sept. 29	13^{h}	41^{m}	36^{s}	+ 13°	4′	1·00
Oct. 3	13	45	28	16	26	
7	13	48	40	19	29	
11	13	51	32	+ 22	18	0·52

J. G. Lohse.

Lord Crawford's Observatory,
Dun Echt, 1881, September 29.

FROM DUN ECHT CIRCULAR, No. 32.

Mr. W. F. Denning, Ashley Down, Bristol, kindly telegraphs :—

"Discovered bright telescopic Comet in Leo October fourth fifteen hours—

$$\alpha = 9\ \ 22^{m} \qquad \delta = +\ 16^{\circ}$$

Daily motion thirty minutes *east*. Bright central condensation."

An identical telegram has been received from The Astronomer Royal.

RADCLIFFE LIBRARY UNIVERSITY 12 FEB

REPLY TO THE REMARKS OF DR. COPELAND ON MY CALCULATION OF THE PLACE OF THE COMET OF 1733 (this Journal, p. 165).

BY J. A. C. OUDEMANS.

Dr. Copeland is right if he supposes there is an error in my *result*, as the declination of the comet is *north* instead of south; in my calculation I took southern latitude positive and found $\delta = - 18^\circ 35'$, but in communicating my result to Admiral Mouchez I forgot this peculiarity. But I cannot go farther, I do not think the large Right Ascensions deduced by Dr. Copeland have more probability for them than that found by me, and correcting the sign, I believe that my result, RA $= 6^h 5^m$, Decl. $= + 18^\circ 35'$ ($33'$ is a clerical error) is wholly conformable to the ship's log.

Admiral Mouchez has rendered the contents of my letter somewhat freely. I wrote him that the search in the colonial archives at the Hague had revealed nothing extraordinary, except that in the notice about the comet of 1733, in the Cape Journal, there was added "in the firmament in the West," which words Struyck omitted in the passage quoted by Admiral Mouchez in the Comptes Rendus (and by Dr. Copeland, p. 164, l. 13 and 14 from the bottom). But I remarked that the work of Struyck which he had consulted, was the *Vervolg* (the continuation) of his description of comets.

The principal work of Struyck on comets, "Korte Beschryving van alle de comeeten of staartsterren, die ik in de geschiedenissen heb kunnen vinden," is buried in his "Inleiding tot de algemeene geographie, benevens eenige sterrekundige en andere verhandelingen" (Amsterdam, by Isaac Tirion, 1740). There we find on p. 300 (I give the translation): "In the year 1733, on the 17th of May Sunday evening, in the 'Platvoet' (evening watch, 4 to 8 p.m.) being in latitude 34° 59′ and longitude 39°, having in sight the land of the False Bay, there was seen a comet in the North West by West, the tail was directed upwards and seemed to the eye to have a length of two feet, it was seen a full hour till it set. *This is drawn from the log of the ship Ypenroode.*" (Struyck italicises.)

For want of an ephemeris for 1733 I used the *Berliner Jahrbuch* for 1833, and as 100 tropical years = 36524·22 days = 100 Gregorian years + $0^d{\cdot}22$, I took the Sun's place from this ephemeris for May 17·33, RA $3^h 37^m$, Decl. $+ 19^\circ 26'$. Taking $\phi = \text{S } 34^\circ 59'$ I found sunset at $5^h 3^m$ app. time, and Sun 16° below the horizon at $6^h 24^m$ app. time.

Assuming this to be the moment the comet commenced to be visible, in an azimuth of N. 56° 15′ W., and that the setting of the comet took place at $7^h 34^m$, the problem is a determinate one. Calling t the hour-angle at $6^h\ 24^m$, $\theta = 1^h\ 10^m = 17^\circ\ 30'$, a the azimuth $56^\circ\ 15'$, $\phi = +\ 34^\circ\ 59'$, we have—

$$\text{tang}\ \delta = \text{tang}\ \phi \cos t - \frac{\sin t}{\cos \phi\ \text{tang}\ a} = -\cos(t + \theta) \cot \phi,$$

$$\text{tang}\ t = \frac{\cos^2 \phi \cos \theta + \sin^2 \phi}{\cos^2 \phi \sin \theta + \sin \phi \cot a}.$$

I find—

$$\begin{aligned} t &= 58^\circ\ 53' = 3^h\ 56^m \\ t + \theta &= 76\ \ 23 \\ \delta &= -\ 18^\circ\ 35' = \text{North}\ 18^\circ\ 35' \\ \text{RA} &= 3^h\ 37^m + 6^h\ 24^m - 3^h\ 56^m = 6^h\ 5^m. \end{aligned}$$

This RA is much less than that of Dr. Copeland. Taking his places for the comet, either $7^h\ 30^m + 12^\circ$ or $8^h\ 3^m + 25^\circ$ (+ being north) I find the apparent time of setting of the comet either $9^h\ 16^m$ or $8^h\ 59^m{\cdot}5$. It should then have been visible almost three hours, whereas the log recorded a full hour (een groot uur), which I interpreted by $1^h\ 10^m$.

Regarding the use either of the corrected or the uncorrected compass-bearing, I consulted a naval officer, who told me that on board Dutch ships, in recording such phenomena, the custom was to take the corrected or true bearings.

If the comet had really a RA not larger than $6^h\ 5^m$, it is not so strange that it was not seen in Europe. In fact it followed the Sun nearly on the same parallel, at the distance of 37°, and I find, *e.g.*, that for a latitude of 52° north, the comet set at $10^h\ 5^m$ app. time, when the Sun was only 14° 17′ below the horizon.

In the ship's log the bearing of the comet was called N.W. by W. (Dutch, Noord West ten Westen). Dr. Copeland writes N.W. $\frac{1}{4}$ W., probably following the French of Pingré, Nord-ouest-quart-ouest, but this is the right name for N.W. by W. In Dutch N.W. $\frac{1}{4}$ W. signifies a bearing of N. 47° 49′ W.*

Utrecht, September 1881.

MARKREE OBSERVATIONS OF RED STARS.

By W. DOBERCK.

With a few exceptions the following observations were made with a Munich cometseeker, with which I have also noted the difference in brightness between the red stars and neighbouring objects. It would take too much space to publish these comparisons, but I shall be most happy to place them at the disposal of any observer. Concerning the objects not in Birmingham's catalogue, I must confess that I find it difficult to decide what intensity of colour renders a star worthy of being catalogued. The heavens abound of course in stars of a more or less pale red tint. Many such objects I have marked on the map but have here inserted only a few prominent ones.

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* In point of fact the comet's place had been computed by me on the assumption that it was first seen about 8^h and set about 9^h in accordance with the account in Comp. Rend. XCIII., p. 173. Dr. Oudemans' result is probably nearer the truth, despite there still being a want of direct evidence as to the time when the comet was first seen. I was certainly mistaken as to the bearing, believing that "nord-ouest-quart-ouest" meant N.W., $\frac{1}{4}$ W. whereas it corresponds to N.W. by W. This mistake is perhaps the more pardonable as the bearing is printed N O $\frac{1}{4}$ O in the Comptes Rendus, which is however the French method of expressing N.W. by W. and therefore indicates a bearing $\frac{3}{4}$ of a point to the west of the English N.W. $\frac{1}{4}$ W. R.C.

Name.	R.A. 1880.	Decl. 1880.	Date.	Magn.	Colour.	Remarks.
B. 11,	0h 50m	+ 67° 3′	1880, Feb. 8	9	Reddish.	
B. 23,	1 19	+ 65 27	„ „ 8	—	Reddish.	
B. 45,	2 28	+ 65 14	„ „ 8	6	Slightly red.	
			„ Mar. 8	6	Not very red.	
B. 51,	2 47	+ 63 50	1879, Sep. 23	6·7	Orange red.	
			„ Oct. 14	5·9	Orange red.	
			1880, Feb. 8	6	Sparkling red.	
			„ „ 14	6·5	Red.	
			„ Mar. 8	5 ±	Good red.	
B. 57,	3 4	+ 47 16	„ Feb. 8	7	Hardly red,	Through clouds
Nova,	3 14	+ 64 9	„ „ 8	5·5	Glowing red,	B.D. 64°391
Nova,	3 18	+ 71 26	„ „ 8	7·0	Reddish-white,	B.D. 71°201
B. 62,	3 22	+ 47 35	„ „ 8	5	Red.	
B. 69,	3 38	+ 65 9	„ „ 8	5	Yellow.	
B. 71,	3 47	+ 60 45	„ „ 8	6	Yellow.	
B. 85,	4 44	+ 28 19	1879, Sep. 23	6·5	Very red.	
			„ Oct. 14	6·9	Reddish,	Through clouds
B. 88,	4 47	+ 2 18	1880, Jan. 30	5·5	Red.	
B. 89,	4 49	+ 7 35	„ „ 30	6	Yellow.	
B. 95,	4 56	+ 0 33	„ „ 30	5	Yellow.	
B. 96,	4 59	+ 1 1	„ „ 30	5·3	Fiery red.	
B. 100,	5 4	— 0 43	„ „ 30	7	Faint red.	
Nova,	5 8	+ 5 1	„ „ 30	—	Red,	B.D. 4°877
B. 102,	5 9	— 0 42	„ „ 30	7	Faint red.	
B. 110.	5 24	— 1 11	„ „ 30	6	Faint red.	
Nova,	5 43	+ 2 41	„ „ 30	—	Very yellow,	B.D. 2°888
Nova,	6 2	+ 22 13	„ Feb. 14	6·0	Pale red,	B.D. 22°1198
B. 136,	6 5	+ 21 54	„ „ 14	6	Very red.	
B. 137,	6 5	+ 22 56	„ „ 14	6	Red.	
B. 142,	6 13	+ 14 42	„ „ 14	6	Orange red.	
Nova,	6 19	+ 11 18	„ „ 14	7·5	Faint red,	B.D. 11°1166
B. 144,	6 19	+ 14 47	„ „ 14	7	Very red.	
Nova,	6 22	+ 2 44	„ „ 14	6·7	Pale red,	B.D. 2°1253
B. 146,	6 24	+ 0 2	„ „ 14	8·5	Very red.	
B. 149,	6 29	+ 0 7	„ „ 14	9·5	—	
B. 168,	7 6	+ 82 38	„ Jan. 21	—	Yellow.	
B. 170,	7 8	+ 22 11	„ Feb. 14	6·8	Pale red.	
Nova,	7 14	+ 20 40	„ „ 14	5·7	Pale red,	B.D. 20°1775
B. 177,	7 22	+ 21 11	„ „ 14	8·3	Hardly red.	
B. 182,	7 34	+ 23 19	„ „ 14	6	Pale red.	
B. 187,	7 37	+ 5 14	„ „ 14	7·5	Red.	
Nova,	7 41	+ 5 43	„ „ 14	7·6	Reddish,	B.D. 5°1790
B. 209,	8 46	+ 19 46	„ „ 14	8	Slightly red.	
B. 211,	8 49	+ 17 41	„ „ 14	6·6	Fiery red.	
B. 221,	9 14	+ 0 41	„ „ 14	6·8	Red.	
Nova,	10 49	+ 23 0	„ „ 20	—	Suspected to be pale red,	B.D. 23°2279
B. 251,	10 56	+ 20 49	„ „ 20	—	Not at all red.	
			„ Mar. 8	—	Perhaps yellowish.	
B. 256,	11 9	+ 23 45	„ Feb. 20	5	Reddish-yellow.	
			„ Mar. 8	—	Orange.	
B. 259,	11 12	+ 33 45	„ „ 8	—	Good red,	Many ruddy stars near
			„ „ 18	—	Orange.	
B. 265,	11 35	+ 25 28	„ Feb. 20	8·2	Faint red.	
			„ Mar. 18	8·5	Faint red.	
Nova,	11 38	+ 25 54	„ „ 8	—	Orange red,	B.D. 26°2250

Name.	R.A. 1880.		Decl. 1880.		Date.			Magn.	Colour.	Remarks.
B. 276,	12^h	16^m	+ 5°	58′	1880,	Mar.	8	7	White.	
B. 279,	12	21	+ 28	56	„	„	18	—	Yellow.	
B. 281,	12	24	+ 5	5	„	„	8	8·3	Red.	
B. 290,	12	39	+ 46	6	„	Feb.	20	5·5	Very red.	
B. 294,	12	46	+ 17	45	„	Mar.	8	6	Faint red.	
B. 298,	12	52	+ 66	39	„	Feb.	14	6·5	Red.	
B. 299,	12	52	+ 18	25	„	Mar.	8	8	Red.	
B. 300,	12	53	+ 18	3	„	„	8	5	Pale yellow.	
B. 312,	13	36	+ 55	17	„	Feb.	20	5·5	Red.	
B. 315,	13	48	+ 65	19	„	„	14	—	Pale red.	
Nova,	13	49	+ 52	55	„	„	20	7·0	Reddish-yellow,	B.D. 53°1667
B. 320,	14	4	+ 50	1	„	„	20	6	Orange.	
B. 324,	14	9	+ 78	7	„	„	14	5	Pale red.	
B. 325,	14	10	+ 70	0	„	„	14	—	Red.	
B. 328,	14	19	+ 26	15	„	Apr.	8	7·5	Intensely red.	
B. 332,	14	28	+ 76	14	„	Feb.	14	—	Pale red.	
B. 334,	14	30	+ 37	9	„	Apr.	8	6	Pale ruddy.	
B. 337,	14	38	+ 27	2	„	„	8	6	Red.	
B. 341,	14	51	+ 74	39	„	Feb.	14	—	Red.	
B. 342,	14	56	+ 66	25	„	„	14	—	Yellow.	
B. 357,	15	35	+ 77	45	„	„	14	—	Pale red.	
B. 437,	18	17	+ 25	0	1881,	Oct.	15	7·6	White.	
B. 442,	18	21	+ 38	40	„	„	15	7·5	Reddish-white.	
B. 448,	18	28	+ 36	54	„	„	15	8·5	Very red.	
B. 458,	18	39	+ 36	51	„	„	15	7·8	Pale red.	
B. 459,	18	39	+ 39	11	„	„	15	7	Reddish-white.	
B. 461,	18	40	+ 33	4	„	„	15	8	White.	
B. 476,	18	53	+ 38	38	„	„	15	8	Reddish.	
B. 541,	20	9	+ 38	22	„	„	15	8	Reddish-white.	
B. 551,	20	13	+ 40	0	„	„	15	—	Yellow.	
Nova,	20	15	+ 38	38	„	„	15	7·5	Reddish,	B.D. 38°4003
B. 554?,	20	17	+ 36	32	„	„	15	9	White.	
Nova,	22	7	+ 34	0	1880,	Sep.	10	6·0	Red but very pale,	B.D. 33°4456
B. 607,	22	9	+ 39	7	„	„	10	—	Yellow, perhaps pale red.	
B. 608,	22	11	+ 37	9	„	„	10	—	Red but very pale.	
B. 615,	22	34	+ 56	10	„	Jan.	20	6	Yellowish-white.	
B. 622,	22	47	+ 42	40	„	„	20	5·5	Pale red.	
Nova,	22	51	+ 49	6	1881,	Oct.	15	6	Pale red (bright stars of different colour near).	B.D. 48°3887
B. 637,	23	14	+ 22	26	1879,	Oct.	27	5·5	White, perhaps slightly ruddy.	Thick air
					1880,	Sep.	10	6·7	Reddish.	
B. 642,	23	26	+ 23	11	„	„	10	6·2	Pale red.	
B. 643,	23	27	+ 21	52	„	„	10	5·5	Reddish-yellow.	
B. 647,	23	38	+ 28	42	„	„	10	—	Pale-yellow or perhaps reddish. An 8 mag. star south of it seems redder.	
Nova,	23	46	+ 20	58	„	„	10	6·3	Pale red,	B.D. 20°5386
B. 653,	23	51	+ 21	59	„	„	10	6	Pale red.	
B. 655,	23	52	+ 24	29	„	„	10	—	Pale yellow.	
B. 658,	23	55	+ 59	41	1881,	Oct.	15	8	Red.	

OBSERVATIONS MÉRIDIENNES ET ORBITE DE LA COMÈTE *b* 1881.

J'ai l'honneur de vous communiquer l'ensemble des observations méridiennes de la grande comète *b* de 1881, qui a été vue ici pour la première fois le 24 Juin, faites à l'Observatoire de Madrid. Ces observations avaient été deja envoyées à M. Copeland (et les deux premières furent insérées dans le "Dun Echt Circular" No. 24), mais, postérieurement, en examinant de nouveau les réductions, faites alors trop à la hâte à cause des circonstances, on y a trouvé quelques erreurs, qui ont été corrigées dans le tableau suivant, où les déclinaisons sont encore affectées de la parallaxe—

1881.	Temps moyen de Madrid.	Ascension droite apparente.	Déclinaison apparente.	Observateur.
Juin 26,	11^h 26^m 41^s·9	5^h 47^m 36^s·73	+ 56° 59′ 17″·8	Ventosa
„ 27,	28 1·3	52 52·89	60 15 5·5	La Cruz
„ 28,	29 59·2	58 47·7?	63 11 24·0	„
„ 29,	32 37·6	6 5 23·03	65 49 19·2	„
Juillet 3,	51 45·6	40 20·38	73 46 28·8	„
„ 4,	59 4·1	51 36·7	75 13 48·0	„
„ 5,	12 7 32·8	7 4 3·3	76 30 25·1	Ventosa
„ 6,	17 12·8	17 41·5	77 37 23·7	„
„ 7,	28 5·7	32 32·7	78 35 24·7	„
„ 8,	40 8·8	48 34·4	79 25 14·1	„
„ 12,	13 37 24·3	9 1 45·5	81 33 52·7	Jimenez.
„ 13,	52 48·8	21 9·1	81 51 6·4	„
„ 15,	14 22 51·5	59 9·8	82 11 47·8	„

L'ascension droite correspondante au 28 Juin est un peu incertaine, n'ayant pas été observée que sur un seul fil à cause des nuages.

Il était intéressant de savoir quel degré de précision pouvaient offrir nos observations. En conséquence, j'ai calculé, avec toutes, l'orbite parabolique la plus probable, et j'ai obtenu les éléments suivants—

$$\begin{array}{rl} T = & \text{1881, Juin 16·45857 T. m. de Greenwich} \\ \left.\begin{array}{r} \pi = \\ \Omega = \\ i = \end{array} \begin{array}{l} 265^\circ\ 14'\ 43''{\cdot}7 \\ 270\ \ 58\ \ \ 6{\cdot}6 \\ 63\ \ 28\ \ 27{\cdot}6 \end{array}\right\} & \text{Eq. moyen 1881·0} \\ \log q = & 9{\cdot}865809 \end{array}$$

Les observations de Madrid sont représentées par cette orbite comme il suit—

1881.	O — C. $\cos\beta\, d\lambda$	O — C. $d\beta$
Juin 26,	+ 0″ 6	+ 1″·5
„ 27,	— 1·3	+ 0·1
„ 28,	+ 3·6	+ 0·2
„ 29,	— 1·3	— 2·4
Juillet 3,	— 0·1	— 2·8
„ 4,	— 2·2	+ 1·2
„ 5,	— 0·1	0·0
„ 6,	— 0·6	+ 2·5
„ 7,	+ 0·2	— 0·6
„ 8,	— 0·5	+ 1·1
„ 12,	— 0·4	+ 1·0
„ 13,	+ 2·2	— 1·2
„ 15,	— 0·6	— 0·2

Dans le calcul on a donné le même poids à toutes les observations.

Observatoire de Madrid,
le 23 Octobre 1881.

V. VENTOSA.

DENNING'S COMET *f* 1881.

From Dun Echt Circular No. 33 (Oct. 14) :—

"Elements, Ephemeris and Description, telegraphed in 24 words from Boston, U.S., by the 'Science Observer Code.'

$$\begin{array}{rl} T = & 1881, \text{ September } 3{\cdot}47 \text{ Greenwich M. T.} \\ \left.\begin{array}{r}\pi - \Omega = \\ \Omega = \\ i = \end{array}\begin{array}{rr} 297^\circ & 46' \\ 82 & 29 \\ 10 & 25\end{array}\right\} & \text{Mean Equinox } 1881{\cdot}0 \\ \log q = & 9{\cdot}8606\end{array}$$

"These Elements were computed by Mr. S. C. Chandler Jr. from Harvard College observations on Oct. 10 and 11 and a Dun Echt place of Oct. 9 cabled to Boston by special request.

Ephemeris for Washington Midnight.

1881	α	δ	Brightness.
Oct. 12,	9ʰ 41ᵐ 12ˢ	+ 14° 50′	0·71
„ 16,	9 49 24	14 52	
„ 20,	9 57 4	14 56	
„ 24,	10 4 4	+ 15 0	0·45

"The orbit presents some resemblance to those of comets 1819 IV and 1771 I. The comet is described as circular, 1′ in diameter, of the 10th magnitude, with some central condensation, but no tail."

(These remarks occupy but 5 words of the message.)

From Dun Echt Circular No. 34 (Oct. 15) :—

This Comet was observed at Dun Echt—

1881	D. M. T.	App. α	App. δ
Oct. 9,	16ʰ 45ᵐ 10ˢ	9ʰ 34ᵐ 30ˢ·25	+ 14° 48′ 1″·4
„ 10,	16 1 26	9 36 39·39	14 48 54·8
„ 12,	14 58 14	9 40 56·85	14 49 59·5

From these observations Mr. Lohse and the undersigned deduced the following Elements and Ephemeris :—

$$\begin{array}{rl} T = & 1881, \text{ September } 12{\cdot}0943 \text{ Greenwich M. T.} \\ \left.\begin{array}{r}\pi - \Omega = \\ \Omega = \\ i = \end{array}\begin{array}{rrr} 309^\circ & 18' & 24'' \\ 72 & 47 & 45 \\ 7 & 45 & 12\end{array}\right\} & \text{Mean Equinox } 1881{\cdot}0 \\ \log q = & 9{\cdot}859822\end{array}$$

Ephemeris for Greenwich Midnight.

1881	α	δ	log *r*	log Δ
Oct. 20,	9ʰ 56ᵐ 44ˢ	+ 14° 51′	0·01748	0·01599
„ 24,	10 3 54	14 50	0·03918	0·02910
„ 28,	10 10 27	14 50	0·06038	0·04051
Nov. 1,	10 16 23	+ 14 51	0·08090	0·05030

RALPH COPELAND.

Dr. Oppenheim telegraphed from Berlin by the "Science Observer Code" approximate elements and ephemeris of comet *f* (Dun Echt Circular No. 35, Oct. 18). The following more detailed information has been received by letter:—

"Aus den Beobachtungen Marseille Oct. 5, Dun Echt Oct. 9 und 12 erhielt ich folgende Elemente.

$$\begin{array}{l} T = 1881,\ \text{Sept. } 12{\cdot}4930 \text{ m. Z. Berlin} \\ \left.\begin{array}{r@{\;=\;}l} \omega & 309^\circ\ 41'\ 35'' \\ \Omega & \ \ 72\ \ \ \ 2\ \ \ 59 \\ i & \ \ \ \ 7\ \ \ 37\ \ \ \ 0 \end{array}\right\}\ \text{Mittl. Aeq. } 1881{\cdot}0 \\ \log q = 9{\cdot}85860 \end{array}$$

Darstellung der mittleren Beobachtung $\delta\lambda = +1'\ 21''$, $\delta\beta = -0'\ 29''$."

Monsieur L. Schulhof of Paris writes (Dun Echt Circular No. 36, Oct. 25):—

"J'ai l'honneur de vous communiquer les éléments elliptiques de la comète Denning, basés sur Marseille oct. 5, Dun Echt oct. 9, 10 et 12, Paris oct. 18.

$$\begin{array}{r@{\;=\;}l} T & 1881,\ \text{sept. } 13{\cdot}077067 \text{ t. m. de Berlin} \\ \pi - \Omega & 312^\circ\ \ 4'\ 17''{\cdot}5 \\ \Omega & \ \ 65\ \ \ 51\ \ \ 34{\cdot}4 \\ i & \ \ \ \ 6\ \ \ 51\ \ \ 44{\cdot}9 \\ \log q & 9{\cdot}859675 \\ \log e & 9{\cdot}911127\ (\phi = 54^\circ\ 34'\ 54''{\cdot}2) \\ \log a & 0{\cdot}592370 \end{array}$$

Durée de révolution $7\frac{3}{4}$ ans.

Ces éléments laissent dans le lieu moyen les erreurs

$$\Delta\lambda \cos\beta = +5'', \qquad \Delta\beta = 0$$

et sont encore bien incertains.

Erreur de la parabole

$$\Delta\lambda \cos\beta = -211'', \qquad \Delta\beta = -1''."$$

Mr. S. C. Chandler Jr. of Harvard College Observatory has telegraphed the following elliptic Elements of Comet 1881 *f*, (Denning). (Dun Echt Circular No. 38 (Nov. 3):—

$$\begin{array}{l} T = 1881,\ \text{September } 13{\cdot}05 \text{ Greenwich M. T.} \\ \left.\begin{array}{r@{\;=\;}l} \pi - \Omega & 312^\circ\ 1' \\ \Omega & \ \ 66\ \ \ 9 \\ i & \ \ \ \ 6\ 53 \end{array}\right\}\ \text{Mean Equinox } 1881{\cdot}0. \\ \log q = 9{\cdot}8597 \\ \log e = 9{\cdot}9160 \end{array}$$

Period: 8 years and 4 months.

Ephemeris of Comet 1881 *f*, computed by Dr. Oppenheim:—

1881	α	δ	$\log r$	$\log \Delta$	Brightness
Nov. 3	$10^h\ 18^m\ 35^s$	$+14^\circ\ 54'{\cdot}5$	0·0888	0·0503	0·30
5	10 21 7	14 56·4			
7	10 23 30	14 58·7	0·1084	0·0582	0·26
9	10 25 44	15 1·4			
11	10 27 49	15 4·5	0·1273	0·0649	0·23
13	10 29 47	15 8·0			
15	10 31 34	+15 12·1	0·1455	0·0704	0·21

The brightness on October 5 is taken as unity.

POLARISCOPIC OBSERVATIONS OF COMET *c* 1881.

BY ARTHUR W. WRIGHT.

(From the American Journal of Science, November 1881, communicated in advance by the Author.)

The path of this comet in the sky did not bring it into positions the most favourable for observation, but while near the perihelion it continued for a short time each evening at a sufficient altitude to escape the influence of twilight, though, never far enough above the horizon to be viewed under entirely satisfactory conditions. Although these circumstances prevented the attainment of anything like a complete series of observations, it was found possible to establish the fact of polarization, and even to secure some measurements. Owing to the extreme faintness of the light, these were obtained with some difficulty, and were limited to a small number.

The first successful observation was made on August 16, from 9^h to 10^h p.m., local time. With a double-image prism, placed before the eye-piece of a comet-seeker having an aperture of three inches, and a magnifying power of about eight diameters, the light was easily seen to be polarized in a plane passing through the sun. That there might be no doubt upon this point, two other persons were requested to view the images as they appeared in the instrument. Both found one of them fainter in certain positions of the prism, and in every case correctly designated that one which accorded with polarization in the direction above described, and this without any intimation as to the result to be expected. The light was just sufficient, when the polarimeter was applied, to enable the bands to be seen with great difficulty, but measurements were impossible.

A few evenings later some polarimetric determinations were obtained, the results of which are brought together in the annexed table. The instrument and method employed were the same as described in the account of observations upon comet *b*.* Column I gives the date and local time; in column II each number is the per-centage of polarization derived from ten separate measurements; column III gives the mean of these for each evening; in column IV are given the angles of incidence of the solar rays. These are obtained by graphic interpolation from a curve representing the angles calculated from the ephemeris of H. Oppenheim,† for the dates there given.

I.	II.	III.	IV.
Aug. 20, $8^h\ 30^m$ to 9^h 30, P.M.	13·4 14·2	13·8	54°·6
Aug. 22, $8^h\ 30^m$ to 9^h 15, P.M.	11·0 9·7	10·3	55°·6
Aug. 25, $8^h\ 30^m$ to 9^h, P.M.	10·5 11·6	11·0	55°·2
Aug. 27, $8^h\ 30^m$ to 9^h, P.M.	[16·8]	[16·8]	54°·1

The per-centage for August 27 was obtained from two settings of the plates only, and is entitled to less confidence than the others. That the polarization was really increasing, however, was easily recognized by the appearance of the bands, and their relative brightness in the two positions of the glass plates. After this date the condition of the sky was not at any time such as to render further determinations possible. At the hours of the observations the last vestiges of twilight had apparently disappeared; and a careful examination of the neighbouring regions of the heavens with the instrument failed to give evidence of its presence, or of any polarization in the very faint light of the sky.

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* Amer. Journal, Vol. XXII, Aug., 1881, p. 142; Copernicus, Vol. I., p. 157.

† Astron. Nachr., No. 2388, p. 190.

A comparison of the results above given with those obtained in my observations of comet *b*, 1881, shows that for corresponding angles of incidence the polarization was decidedly less than in the case of the latter comet. There appears also to be a difference in the relation of the per-centages to the angles of incidence. Comet *c*, during the period when measurements were possible, changed its position in such a way that the angle first increased and then decreased, the change in each case being very small. It is so little, in fact, that some uncertainty must be felt as to its character, since the data of the published ephemerides lead to considerably different values. That of Oppenheim, however, which was employed in computing the series, as above mentioned, agrees very well with reported observations of position of the comet made during the period covered by the dates in the table. The results found as above indicate that the polarization, for this comet, conforms in general to the law of variation for a gaseous medium, where the curve representing it has the maximum at the incidence of 45°, and changes very rapidly in the region corresponding to the incidences given in the table.

In the case of comet *b*, the largest angle of incidence was nearly 60°, and as this diminished the polarization was seen to diminish likewise; but it happened that at the times of widest incidence the comet was near its perihelion. A maximum occurring with an incident angle as large as 60° would hardly be looked for if the degree of polarization depended upon this angle alone. If the reflecting material were wholly gaseous the greatest polarization should be found at 45° incidence; but though a tendency toward a secondary maximum at this angle may be suspected the observations are not sufficient to definitely establish its existence. The changes actually observed are with difficulty reconciled with the supposition that the reflection took place from gaseous substance alone. It is not improbable that, as the comet was nearing the sun, and while it remained near the perihelion, some form of volatizable matter may have been eliminated by the increasing temperature, and that the subsequent condensation of this gave rise to the presence of minute liquid or solid particles in the gaseous matter first thrown off. The varying, proportions of these two forms of matter might be the cause of notable variations in the total amount of light polarized. It is, of course, not to be overlooked that the substance of the coma, and probably that of the tail, gives out light of itself. The action just described must alter the relation of the emitted to the reflected rays, and this would have its effect upon the degree of polarization.

The earlier observations of comet *b*, made soon after its perihelion passage, show occasional irregularities, and the variations are in some cases decidedly greater than the ordinary errors of observation. The sky at the time appeared very clear, and the atmospheric conditions were probably not the sole cause of the fluctuations. It seems almost certain that at this period of great activity the polarization was subject to considerable variations of an irregular character and comparatively brief duration.

Yale College, October 15, 1881.

RECENT LITERATURE.

"*Celestial Objects for Common Telescopes. By the Rev. T. W. Webb. Fourth Edition, revised and greatly enlarged.*" (London, 1881, Longmans & Co., 493 pp.) This charming little work is so well known as to require no eulogy on our part. The new edition which has been looked forward to for several years, since the third edition went out of print, has been thoroughly revised throughout and the second half, on "the starry heavens," has been increased nearly to double its former extent. The Author remarks that the last seven years have brought such an unprecedented increase of observers and instruments competent to deal with a more difficult class of objects, that it was thought desirable without abandoning the original design or title of the work, to enlarge it in the hope of greater usefulness. An addition has accordingly been made of about 1080 pairs from the Dun Echt Summary of Struve's Double Stars, together with 70 from the Pulkova catalogue and many from Burnham's lists. The nebulæ do not appear to have been increased considerably in number, and these objects have perhaps hardly been attended to in the same degree as the double stars. The plate of the supposed transit of the comet of 1819 and the four pages of references to observations of small opaque bodies crossing the Sun, it might probably have been better to leave out altogether.* Particularly on account of the many observations of detail on the surfaces of the large planets which are given in the book, it seems a pity that the Author has not given any references. Mr. Burton's map of Mars (see above, p. 66) is added to the chapter on this planet. The new edition will no doubt become as great a favourite as the preceding ones.

"*Annual Report of the Director of the Dearborn Observatory, Chicago.*" From Professor Hough's report it appears that the surface of Jupiter was especially studied with the Chicago Refractor between May 1880 and January 1881. The principal features remained permanent during this period, while minor changes took place gradually and slowly. Nearly 1400 micrometer measures were taken of the red spot, the equatoreal belt, the white spots and the polar spots. The discussion of the longitude measures of the red spot made from Sept. 25, 1879, to Jan. 27, 1881, gives the value for the rotation $9^{h}\ 55^{m}\ 35^{s}{\cdot}2$, but when the single observations are compared with this value, a well marked maximum displacement of the centre of the spot is found, amounting to $1''{\cdot}4$ and indicating that the centre gradually oscillated to this extent, corresponding to an actual displacement of 3200 miles on the surface of Jupiter. The period $9^{h}\ 55^{m}\ 33^{s}{\cdot}2 + 0{\cdot}18\sqrt{t}$ (t being the number of days from Sept. 25, 1879) satisfies all the observations with a mean maximum error of $0''{\cdot}5$. Measures of the red spot in 1879 and 1880 indicate a very remarkable degree of permanency as to the size, shape and latitude of the spot. Five determinations of the period of rotation from observations of polar spots gave the mean result $9^h\ 55^m\ 35^s{\cdot}1$. Two white spots near the equator were followed for about three months and gave values about 5½ minutes smaller, the motion of the spots appearing to be perfectly uniform. In the Chicago refractor a satellite when crossing the disk of the planet usually disappears when from one fourth to one third across the disk and reappears at an equal distance from the preceding limb, proving that the centre of the disk is more luminous than the satellite. The first satellite has sometimes been seen in transit as a greyish spot, even on the middle of the disk. Once (July 3, 1880) the second satellite passed almost directly over the centre of the red spot, and appeared as bright as when off the disk. On November 1, 1880, Professor Hough witnessed the transit of the shadow of the second satellite over the centre of the red spot while the shadow of the first satellite was passing over the disk. When fully projected on the red spot the shadow was distinctly visible, though not being as black as the other shadow on the disk.

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* The two objects seen by Lummis (1862) and Weber (1876) which have most conclusively been shown to be sun-spots, should at all events have been excluded.

Professor Hough remarks that what we want, are not sketches and general statements, but measures from which may be deduced the motions and changes taking place on the surface of Jupiter. He suggests, that the various phenomena might be explained by supposing the surface to be covered with a liquid semi-incandescent mass, and the belts and other dark markings to be composed of matter at a lower temperature, while the egg-shaped polar-spots are openings in the semi-fluid crust. This hypothesis would account for the slow and gradual changes, which are not reasonably explained on the simple atmospheric theory. The equatoreal white spots might be cloud-like masses formed in an atmosphere over the liquid surface.

Professor Colbert has computed an orbit and ephemeris for the companion of Sirius. The elements are—

Semi-axis major	8″·42	Excentricity	0·58
Mean motion	7°·26	Period	$49^y{\cdot}6$
Inclination	57°·1	Node	42°·4

This orbit gives the following places—

1881·2	Pos.	45°·5	Dist.	9″·9
1883·2		40 ·4		8 ·8
1885·2		33 ·5		7 ·4

Mr. Burnham, who had the use of the great refractor, discovered about fifty new double stars from May 1880 till April 1881, when he left for Madison. He also made about 600 measures of previously known double stars.

"*South African Philosophical Society; Dr. Gill's Address, 29th July* 1881." (12 pp. 4to.) From this address it appears that at the Cape Observatory during the past two years a good deal of attention has been directed to occultations of stars by the Moon. The clear skies at the Cape permit the observation of three times as many occultations as can be observed in England in the same time. When reduced, these observations will be placed in the hands of Professor Newcomb to aid in his researches on the motion of the Moon. Waiting for comparison with Mr. Stone's great catalogue is a catalogue of 5000 Southern stars observed between 1848 and 1852 and lately reduced. Allusion is also made to the observations of about 500 stars, which are being made at Leyden and the Cape as already mentioned above (p. 200). At the time when the address was delivered, preparations were being made to determine telegraphically the difference of longitude between Aden and the Cape in order to connect the Cape with Greenwich and Berlin through the previously determined differences Aden – Suez, Suez – Alexandria, Alexandria – Malta, Malta – Berlin. The First Assistant, Mr. Finlay, was on his way to Aden to exchange signals through the nearly 3,000 miles of submarine cable connecting Aden with Durban. A Thompson's reflecting galvanometer was to be used for the signals.

"*Catalogue of* 12,441 *Stars for the epoch* 1880 ; *from observations made at the Royal Observatory, Cape of Good Hope, during the years* 1871 *to* 1879. *Edward James Stone, M.A., F.R.S. &c.*" (London 1881, XXXII. and 565 pp. 4to.) This Catalogue, published by the Admiralty, is founded on observations made at the Cape Observatory between January 1871 and April 1879. The observing during the whole period was steadily directed to the object in view, the formation of a catalogue of well-distributed stellar zero-points for those portions of the heavens which are beyond the reach of northern observatories. But a considerable number of stars, north of – 25° Decl. were also observed at the Cape and the results have been included in the present Catalogue as a check upon the existence of any systematic errors in the work. Lacaille's well distributed 9766 stars were adopted as the basis of the working list, but as some stars of the sixth and many of the seventh magnitude in Brisbane's Catalogue of 7385 stars had not been observed by Lacaille, the greater part of these were also included in the working list. A large stereographic projection of the southern hemisphere was also prepared, on which were projected the places of all the stars previously observed, and wherever lacunæ appeared within the limits of N.P.D. 115° to 180°, efforts were made to fill them up by observing stars of rather a lower magnitude than the seventh of Lacaille's scale. A reduced copy of this projection accompanies the Catalogue. Generally each star was observed three times.

The Right Ascensions of the stars observed for the determination of the errors of the Transit-clock have been taken from the Greenwich Standard Lists for the different years. The Right Ascensions of Polar stars were taken from Mr. Stone's paper on "The mean places of eight close Southern Polar Stars, 1860 to 1900." The refractions used are those of the Tabulæ Regiomontanæ diminished in the proportion of 0·9988 : 1, but the use of Bessel's tables unaltered would not change the results of the Catalogue by $0''{\cdot}2$. As a proof of the satisfactory character of the adopted refractions, a comparison is given between the results of the Catalogue and the places of the Nautical Almanac for 1880. As might be expected from the use of the same fundamental system, there is a close agreement between the Greenwich and Cape Right Ascensions, but the perfectly independent determinations of N.P.D. are also in very good accordance. Arranging the corrections required by the Nautical Almanac N.P.D.'s in groups of 6 hours of R.A. and applying the general mean correction $-0''.31$ to them all, the following corrections remain:

$0^h - 6^h$	$6^h - 12^h$	$12^h - 18^h$	$18^h - 24^h$
$-0''.24$	$-0''.11$	$+0''.39$	$+0''.06$

The changes in these corrections are systematic, and it appears that the complete reversion of the seasons at the Northern and Southern observatories is not quite accurately allowed for in the refraction tables.

In notes at the end of the Catalogue are given the larger proper motions resulting from a comparison of the Catalogue for 1880 with the "Cape Catalogue for 1840" and Taylor's "Subsidiary Catalogue for 1850." In the Catalogue the mean time of observation is given for all the stars, but in forming the mean positions the proper motion has only been applied in the comparatively few cases where the proper motion is given in the body of the Catalogue. The latter contains in separate columns references to Piazzi, Brisbane, Fallows, Johnson, Henderson, Taylor, Cape 1840, Cape 1860 and Melbourne 1870, and in foot-notes other references as also corrections to previous catalogues and remarks about duplicity, false positions &c. Lacaille's numbers are given in the second column, next to the current number of the Catalogue. The constellations occupy the third column; Lacaille's system is used, with the modifications proposed by Sir J. Herschel.

The importance of this great work can hardly be over-estimated. Valuable as the two previously published Cape Catalogues and the Melbourne Catalogue for 1870 are, they cannot compare with it either as regards extent or completeness, and when it is remembered how uncertain the foundation is, on which Lacaille's Zones rest, and how poor and unreliable the Brisbane Catalogue is, it will be conceded by everybody, that Mr. Stone's Catalogue will be an inestimable treasure for future generations, the value of which will continue to increase. As remarked by its Author, the Catalogue may also render good assistance in investigations on special stars occurring in Lacaille's and Brisbane's catalogues, or even in completely new re-reductions of the observations on which these catalogues are founded.

"*Catalogue of* 1098 *Standard Clock and Zodiacal Stars, prepared under the direction of Simon Newcomb.*" (Papers prepared for the use of the American Ephemeris, No. 4; 162 pp. 4to.) This catalogue was prepared for the purpose of obtaining standard positions of reference stars for use in the lunar and planetary theories, especially in the reduction of the older occultations. It contains all the standard stars of the Ephemeris (except most of those added for field work) and all stars to the sixth magnitude inclusive, which can be occulted by the Moon, together with stars below the sixth magnitude observed by Bradley. The Author was able to use Auwers' reduction of Bradley. The declinations of the catalogue are reduced to Mr. Boss' system, which was only modified so far as to substitute Auwers' reduction of Bradley for that of Bessel. In the case of stars within 30° of the pole the right ascensions were not independently investigated, but were taken from Dr. Gould's catalogue (second edition), while the declinations are those of Mr. Boss. The catalogue gives in the case of the stars observed by Bradley the positions and other data for the two epochs 1755 and 1850, while in the case of fundamental time stars the positions are also given for 1900. Stars between 10° and 30° from the pole have data given for the epochs 1755, 1800, 1850 and 1900, and stars still nearer the pole also for 1825 and 1875. The precessions and secular variations for each epoch are independently computed. Formulæ for finding the place of a star for any epoch between 1750 and 1900 from the data in the catalogue by Taylor's theorem add to the general usefulness of Professor Newcomb's work, which will no doubt be extensively employed by astronomers who have to reduce lunar or planetary observations made during the last and the present century.

"*Photometric Measurements of the Variable Stars β Persei and DM.* 81°25. *By Edward C. Pickering, Arthur Searle, and O. C. Wendell*" (Proc. Amer. Acad., Vol. XVI, 28 pp.). The photometer used at Harvard College Observatory for the observation of these two variables consists of a double-image prism placed between the object-glass and the eye-piece of a small telescope, which has a Nicol prism in front of the eye-piece (see above, p. 79). By this instrument two adjacent stars may be compared with great accuracy, as two images of each will be formed by the double-image prism and their relative brightness may be varied by turning the Nicol. Each image in turn will disappear when the Nicol is turned 90°, and there will consequently always be four positions in which the brighter image of the fainter star will be precisely equal to the fainter image of the brighter star. β Persei was compared with the fifth magnitude star ω Persei, 90′ distant. The two images were formed by two Rochon prisms which produced a separation of about 100′, so that they had to be placed very near the object-glass of the telescope in order that the images of the two stars should be near together. The focal length of the telescope is about seventeen inches, and its available aperture is limited by the size of the prisms to about an inch. Observations were made on thirteen nights, from Sept. 29, 1880, to Jan. 1, 1881. Three settings of each of the four positions of the Nicol constituted a set; the total number of sets was 230. Seven minima were observed, and the probable error of a single minimum is 3·8 minutes, while Schmidt gives the probable error of a minimum observed by Argelander equal to 6 minutes and of those of Schönfeld equal to 4·6 minutes. A comparison is made between the light-curves found by Schönfeld and at Harvard College Observatory, and the photometric and naked-eye methods are found to agree closely.

For the observations of Ceraski's variable star + 81° No. 25 the photometer was attached to the 15-inch refractor, on account of the faintness of the star. 273 sets of measures were made and five minima were observed. The average probable error of a minimum is 1·3 minute, or about one-third of that of β Persei, which was to be expected since the rate of variation of the stars is about as three to one. Some interesting theoretical conclusions are drawn from the resulting light-curve. For about an hour and a half the light remains sensibly constant at 0·110 or about one-ninth of its full intensity. This interval is over one third of that during which the light is increasing or diminishing. If the variation in light is admitted to be due to a dark eclipsing satellite, the diameter of the latter must be $\sqrt{1 - 0{\cdot}110} = 0{\cdot}943$ of that of the star, in order to sufficiently reduce the light. A somewhat smaller diameter is possible if we admit that the star like our Sun is darker near the edges than in the centre. But the difference cannot be great, or it would show itself in other ways. The longest period of uniform minimum light would occur if the satellite produced a central annular eclipse. In this case, if the motion was uniform, the duration of the minimum light would equal only one-ninth of that of increase or decrease. The effect of the curvature or ellipticity of the path would not greatly affect this conclusion. A very great ellipticity is not admissible, or at the periastron the satellite would strike the star. We are therefore obliged to admit that the star is entirely covered by the satellite, and that the light during the minimum is either due to some proper light of the satellite or is to be explained by admitting that the satellite consists of a cloud of meteors so scattered that about one-ninth of the light of the star can pass through the central portions.

ELEMENTE UND EPHEMERIDE DES COMETEN *e* 1881 (BARNARD).

VON DR. OPPENHEIM.*

"Aus den Beobachtungen angestellt zu Paris 1881 October 1, Leipzig October 11 und dem Mittel aus Kiel und Hamburg October 18, habe ich folgende Elemente des Cometen berechnet:—

$$\begin{array}{rl} T & = 1881,\ \text{September } 13{\cdot}8288 \text{ m. Zt. Berlin} \\ \left.\begin{array}{r} \pi - \text{☊} \\ \text{☊} \\ i \end{array}\right. & \left.\begin{array}{l} = 9^{\circ}\ \ 8'\ 26'' \\ = 269\ \ 23\ \ 38 \\ = 113\ \ 46\ \ 34 \end{array}\right\} \text{ Mittl. Aeq. } 1881{\cdot}0 \\ \log q & = 9{\cdot}69454 \end{array}$$

Ephemeride für 12^h m. Zt. Berlin.

1881	α	δ	log r	log Δ	Helle
Oct. 26,	$13^h\ 50^m\ 55^s$	+ 28° 9′·9	0·0284	0·2026	0·29
„ 30,	13 52 24	30 8·8	0·0555	0·2043	0·25
Nov. 3,	13 53 47	32 7·9	0·0809	0·2051	0·22
„ 7,	13 55 8	34 10·1	0·1047	0·2048	0·20
„ 11,	13 56 29	36 16·6	0·1270	0·2038	0·18
„ 15,	13 57 45	+ 38 28·9	0·1480	0·2021	0·16

Die Helle für October 1 = 1 gesetzt."

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* Issued in Dun Echt Circular No. 37, October 26. We have here only reprinted an abstract of the Ephemeris.

ÉLÉMENTS ET ÉPHÉMÉRIDE DE LA COMÈTE DENNING.

PAR L. SCHULHOF.

J'ai déduit de toutes les observations qui sont parvenues à ma connaissance jusq'au 6 novembre, les éléments suivants :—

$$\begin{aligned}
T &= 1881\text{ sept. }13{\cdot}25866\text{ t. m. de Berlin.}\\
&\left.\begin{aligned}\omega &= 312^\circ\ 21'\ \ 0''{\cdot}4\\ \Omega &= \ \ 65\ \ \ 57\ \ \ 50{\cdot}0\\ i &= \ \ \ \ 6\ \ \ 51\ \ \ 36{\cdot}2\end{aligned}\right\}\ 1881{\cdot}0\\
\log q &= 9{\cdot}860192\\
\log e &= 9{\cdot}916637\ [\phi = 55^\circ\ 37'\ 25''{\cdot}8]\\
\log a &= 0{\cdot}618020
\end{aligned}$$

Le tableau suivant contient, avec les écarts (obs — calc), les 4 lieux employés auxquels j'ai joint un cinquième lieu, formé de deux observations du 3 novembre que j'ai reçues plus tard.

	Temps moyen de Berlin.	λ 1881	Δ λ	β	Δ β	Observations.
I.	1881 oct. 5·7294	139° 3′ 51″·0	0″·0	— 0° 26′ 40″·3	0″·0	Marseille, 1.
II.	„ 11·0	141 44 22·2	+ 1·2	+ 0 35 20·4	— 1·5	Dun Echt, 3.
III.	„ 18·5	145 21 26·7	+ 7·4	+ 1 51 25·3	+ 2·7	Paris, 2 ; Rome, 2 ; Strasbourg, 2.
IV.	„ 30·5	150 23 7·9	0·0	+ 3 33 22·1	0·0	Paris, 1 ; Strasb., 1.
V.	nov. 3·5	151 48 33·3	+ 1·4	+ 4 3 49·5	— 5·0	Marseille, 1 ; Rome, 1.

A l'aide des éléments ci-dessus j'ai calculé l'éphéméride :—

12^h t. m. de Berlin.	α app.	δ app.	log Δ	I.
1881 nov. 15	$10^h\ 36^m\ 33^s{\cdot}46$	+ 14° 42′ 14″·4	0·02056	0·23
16	10 37 34·87	14 43 41·3		
17	10 38 33·91	14 45 19·6		
18	10 39 30·56	14 47 9·8	0·02353	0·21
19	10 40 24·79	14 49 12·2		
20	10 41 16·59	14 51 27·2		
21	10 42 5·94	14 53 55·2	0·02594	0·20
22	10 42 52·81	14 56 36·3		
23	10 43 37·19	14 59 30·9		
24	10 44 19·05	15 2 39·1	0·02786	0·19
25	10 44 58·38	15 6 1·2		
26	10 45 35·16	15 9 37·4		
27	10 46 9·37	15 13 27·8	0·02934	0·18
28	10 46 40·99	15 17 32·6		
29	10 47 10·00	15 21 51·9		
30	10 47 36·40	15 26 25·9	0·03045	0·17
déc. 1	10 48 0·17	15 31 14·7		
2	10 48 21·27	15 36 18·5		
3	10 48 39·67	+ 15 41 37·4	0·03124	0·16

L'éclat de la comète au 5 octobre est pris comme unité.

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RECHERCHES SUR L'ASTRONOMIE DES ANCIENS.

Par H. C. F. C. SCHJELLERUP.

III. *Sur les Conjonctions d'Etoiles avec la Lune rapportées par Ptolémée.*

(3ᵉ chap. du VIIᵉ Livre de l'Almageste.)

En considérant que les observations de la Lune en conjonction avec les Pleïades, l'Épi de la Vierge et les étoiles au front du Scorpion qui se trouvent dans l'Almageste, n'ont pas été soumises jusqu' aujourd'hui à un examen exact, tant que je sache du moins, j'ai cru d'accomplir un ouvrage bien utile en mettant sous les yeux des Astronomes, dans ce qui suit, une comparaison minutieuse entre les observations des Anciens et les meilleures tables de la Lune. Les susdites observations, comptant sept, ont été faites par Timocharis à Alexandrie, par Ménélaus à Rome et par Agrippa à Bithynie (Nikomédie ?) et rapportées dans le 3ᵉ chapitre du VIIᵉ livre de l'Almageste par Ptolémée voulant vérifier la précession découverte par Hipparque.

1. *Conjonction de β Scorpii observée par Timocharis.*
– 294 *Décembre* 20.

Éd. Halma II. page 26.

Πάλιν Τιμόχαρις μέν φησιν, ἐν Ἀλεξανδρείᾳ τηρήσας, ὅτι τῷ λς ἔτει τῆς πρώτης κατὰ Κάλλιππον περιόδου, τοῦ μὲν Ποσειδεῶνος τῇ κε̄, τοῦ δὲ Φαωφὶ τῇ ῑς, ὥρας ῑ ἀρχούσης, ἀκριβῶς σφόδρα ἐφαίνετο κατειληφυῖα ἡ σελήνη τῇ βορείῳ ἀψίδι τὸν πρὸς ἄρκτον τῶν ἐν τῷ μετώπῳ τοῦ σκορπίου.

Timocharis rapportant une observation qu'il a faite à Alexandrie, dit que la 36ᵉ année de la première période de Calippe, le 25 du mois Poseideon, ou le 16 du mois Phaophi, au commencement de la dixième heure, le bord boréal de la Lune paraissait toucher exactement l'étoile la plus boréale du front du Scorpion.

Ptolémée ajoute que la date de cette observation répond à l'année 454 de l'ère de Nabonassar, du 16 au 17 du mois égyptien Phaophi, à 3 heures temporaires après minuit, ou à $3\frac{2}{3}$ heures équinoxiales, parceque le Soleil était alors dans la 26° du Sagittaire (266°). Le temps moyen (en nychtémères égaux *) étant $3\frac{1}{8}$

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* A ce qui regarde réduction de nychtémères vrais en nychtémères égaux, qui du reste n'a aucune influence sur le calcul que nous avons à faire, il en est ainsi. Il est juste, comme Ideler, à qui l'on peut toujours se fier, l'a prétendu, que Ptolémée a placé le commencement de son ère de Nabonassar au midi vrai d'Alexandrie, à l'instant qui selon les tables du Soleil répond à $0^h\ 17^m$ temps moyen d'Alexandrie. Pour établir des jours d'une durée égale, il calcule pour tous les moments l'équation du temps, comme il faut le faire. Mais ayant déplacé l'époque de 17^m, il faut diminuer l'équation calculée de la même quantité. En effet l'équation du temps employée par Ptolémée est à peu près égale à notre équation moins 17^m. A propos de cela nous allons diriger l'attention sur une grave erreur commise par Biot dans son *Résumé de Chronologie astronomique*. Sur page 272, il traite de la question à savoir si l'instant de midi, auquel Ptolémée place l'ère de Nabonassar, se rapporte à un midi vrai ou à un midi moyen.

heures, il trouva que le centre de la Lune était à la distance de 31° 15′ de l'équinoxe d'automne, et 1° 20′ au nord de l'écliptique. La longitude apparente était de 212°, et la latitude 1° 12′, adoptant le temps sidéral au moment égal à 137° (le milieu du Lion était au méridien). La longitude de l'étoile en question était donc 212°, et sa latitude 1° 20′.

La conversion en date julienne s'effectue par les opérations suivantes :

Année de Nabonassar 454, 0 Thot, à midi	=	4419, 308 jours (Novembre 4).
De là jusqu'au 16 Phaophi		46 „
La date julienne sera donc		. 4419, 354 jours (Décembre 20).

Parceque, selon Ptolémée, 3 heures temporaires valent $3^h\ 24^m$ équinoxiales, la date complète de l'observation sera :

Année de la pér. jul. 4419, de l'ère chrétienne — 294, Décembre 20, $15^h\ 24^m$ temps vrai d'Alexandrie, ou $13^h\ 24^m$ à Greenwich.

Pour le 20 Décembre à midi, j'ai trouvé l'équation du temps = + 1^m. La déclinaison du Soleil étant à même époque — 23° 38′, le coucher du Soleil avait lieu, sous la latitude d'Alexandrie,[*] à $4^h\ 59^m$ de temps vrai, d'où il suit qu'une heure temporaire sera égale à $1^h\ 10^m$·3 heures temporaires valent donc $3^h\ 30^m$ temps vrai, s'accordant d'une manière satisfaisante avec le calcul de Ptolémée.

D'après notre calcul le moment exact de l'observation était $13^h\ 31^m$ temps moyen de Greenwich, c'est à dire Décembre 20·563.

D'après les Tables de la Lune par Hansen j'ai trouvé pour le méridien de Greenwich :[†]

— 294 Déc.	*l*	*b*	Π	*r*
20·j500	209° 4′ 44″·4	+ 1° 3′ 11″·1	54′ 19″·6	14′ 49″·7
·525	22 32·7	4 43·9	19·8	49·8
·550	40 21·3	6 16·7	20·1	49·8
·575	58 10·2	7 49·4	20·4	49·9
·600	210 15 59·3	9 22·0	20·8	50·0
·625	33 48·7	10 54·5	21·1	50·1
·650	51 38·3	12 26·9	21·5	50·2

Il partage l'opinion d'Ideler c'est à dire que Ptolémée a établi son ère de Nabonassar, en coïncidence avec le midi vrai d'Alexandrie, mais par des motifs indépendants de ceux sur lesquels Ideler s'appuie. En effet, calculant de *sa* manière l'équation du temps à l'époque de Nabonassar, il trouve 9^m, une quantité qu'il considère assez petite pour pouvoir se permettre de la négliger. Mais, malheureusement sa manière à calculer l'équation du temps est tout à fait fausse ; car, en calculant l'ascension droite moyenne par la formule connue : $\operatorname{tg} a = \operatorname{tg} l \cos \omega$, où l est la *longitude moyenne* du Soleil, il dit que l'équation du temps = ascension dr. vraie — ascens. dr. moyenne ! Il est surtout échappé à Biot, il me semble, que Ptolémée seulement prend soin d'exprimer en temps moyen *les intervalles* entre les observations, et dans cette application son procédé est tout à fait rigoureux.

[*] Nous avons adopté pour Alexandrie : Latitude + 31° 13′, longitude $2^h\ 0^m$ de Greenwich.

[†] Dans la suite je nommerai :—

$$\left.\begin{array}{ll} l \text{ et } l' & \text{la longitude vraie et apparente} \\ b \text{ et } b' & \text{la latitude vraie et apparente} \\ a \text{ et } a' & \text{l'ascension dr. vraie et apparente} \\ \delta \text{ et } \delta' & \text{la déclinaison vraie et apparente} \\ r \text{ et } r' & \text{le semidiamètre vrai et apparent} \\ \Pi_i & \text{la parallaxe équatoreale et horizontale} \end{array}\right\} \text{de la Lune.}$$

$$\left.\begin{array}{ll} A \text{ et } D & \text{l'ascension dr. et déclinaison moyenne} \\ L \text{ et } B & \text{la longitude et la latitude moyenne} \end{array}\right\} \text{de l'étoile.}$$

θ le temps sidéral.

En prenant l'obliquité de l'écliptique $\epsilon = 23° 43' 58''\cdot 0$, on trouvera—

−294 Déc.	α	δ	θ	$\alpha' - \alpha$	$\delta' - \delta$	$l' - l$	$b' - b$	$r' - r$
20·j500	207° 21′ 49″·8	−10° 17′ 49″·2	114° 34′ 39″	+ 47′ 10″·5	− 27′ 1″·2	+ 53′ 1″·0	− 8′ 38″·4	− 2″·0
·525	39 17·4	22 43·7	123 36 8	47 5·4	28 20·4	53 24·3	9 57·4	− 0·2
·550	56 46 0	27 37·4	132 37 37	45 54·7	29 40·2	52 45·4	11 40·5	+ 1·6
·575	208 14 15·5	32 30·3	141 39 6	43 39·3	30 58 3	51 6·8	13 44·5	3·3
·600	31 45·9	37 22·4	150 40 34	40 22·0	32 13·1	48 30·9	16 6·2	4·9
·625	49 17·2	42 13·7	159 42 3	36 7·3	33 22·5	45 0·4	18 42·4	6·5
·650	209 6 49·4	−10 47 4·2	168 43 32	+ 31 0·8	− 34 24·7	+ 40 37·8	− 21 29·9	+ 8·0

où on a calculé $l' - l$ et $b' - b$ au moyen des formules—

$$\Delta l = \sin \eta \sec b \cdot \Delta\delta + \cos \eta \cos \delta \sec b \cdot \Delta\alpha,$$
$$\Delta b = \cos \eta \cdot \Delta\delta - \sin \eta \cos \delta \cdot \Delta\alpha,$$

l'angle de position η étant déterminé par—

$$\sin \eta = \sin \epsilon \cos \alpha \sec b.$$

Pour l'étoile β Scorpii nous avons adopté, suivant nos tables données page 35 de ce journal, pour $-300 + t$:

$$A = 209° 30' 11''\cdot 0 + 47''\cdot 35\, t, \qquad D = -10° 48' 32''\cdot 5 - 17''\cdot 69\, t.$$

On a donc pour − 294, décembre 20 :

$$A = 209° 35' 41''\cdot 2, \qquad D = -10° 50' 36''\cdot 1\,;$$
$$L = 211° 19' 26''\cdot 6, \qquad B = +1° 19' 4''\cdot 8.$$

Il s'ensuit immédiatement—

− 294 Déc.	$\alpha' - A$	$\delta' - D$	$l' - L$	$b' - B$
20·j500	− 86′ 40″·9	+ 5′ 45″·7	− 81′ 41″·2	− 24′ 32″·1
·525	69 18·4	− 0 28·0	63 29·6	24 18 3
·550	53 0·5	6 41·5	46 19·9	24 28·6
·575	37 46·4	12 52·5	30 9·6	24 59·9
·600	23 33·3	13 59·4	14 56·4	25 49·0
·625	− 10 16·7	25 0·1	− 0 37·5	26 52·7
·650	+ 2 9·0	− 30 52·8	+ 12 49·5	− 28 7·8

On verra facilement par ce tableau que la conjonction en longitude avait lieu Décembre 20·626, c'est à dire à $15^h\, 2^m$. La différence en latitude, $b' - B$, étant − 27′·0, ce qui est à peu près la plus courte distance entre le centre de la Lune et de l'étoile, et en se rappelant que le semidiamètre apparent de la Lune était alors 14′ 55″, on comprendra que l'étoile, au lieu de toucher le bord boréal de la Lune, comme le dit Timocharis, se trouvait d'après nos tables à une distance de 12′ de ce même bord.

A ce moment, d'ailleurs qui répond à 160° 3′ 43″ temps sidéral, on a pour β Scorpii—

$$\text{Azimuth} = -56° 41', \qquad \text{Hauteur} = 26° 35'.$$

Enfin je mentionne lorsqu'à minuit de Greenwich ☉ − ☾ = 56°, qu'à $12^h\, 43^m$ l'étoile se levait, et pour le moment que Timocharis assigne, c'est à dire à $13^h\, 31^m$ temps moyen de Greenwich, on a—

$$\theta = 137° 8' 27'', \qquad \text{Azimuth} = -80° 34', \qquad \text{Hauteur} = 4° 38'.$$

2. *Conjonction de α Virginis observée par Timocharis.* — 293 *Mars* 9.

Ed. Halma II. page 23.

Πάλιν Τιμόχαρις μὲν ἀναγράφει, τηρήσας ἐν Αλεξανδρείᾳ, διότι τῷ λς ἔτει τῆς πρώτης κατὰ Κάλιππον περιόδου, τοῦ μὲν Ελαφηβολιῶνος τῇ ῑε̄, τοῦ δὲ Τυβὶ τῇ ε̄, ὥρας γ ἀρχομένης, ἡ σελήνη μέσῃ τῇ πρὸς τὴν ἰσημερινὴν ἀνατολὴν ἀψίδι τὸν στάχυν κατέλαβε, καὶ διῆλθεν ὁ στάχυς ἀφαιρῶν αὐτῆς τῆς διαμέτρου πρὸς ἄρκτους τὸ γ″ μέρος ἀκριβῶς.

Timocharis rapporte (encore) qu'il a vu à Alexandrie, dans la 36ᵉ année de la première période calippique, le 15 du mois Elaphébolion, ou le 5 du Tybi, au commencement de la troisième heure, le milieu du bord de la Lune, tourné vers le levant équinoxial, atteindre l'Épi qui passa derrière elle, retranchant exactement le tiers du diamètre vers le nord.

D'après les calculs de Ptolémée la date de cette observation répond à l'année 454 de Nabonassar, du 5 au 6 Tybi, quatre heures temporaires et équinoxiales avant minuit, le Soleil étant alors dans la 15° des Poissons (345°). Ce temps est sensiblement le même que le temps moyen (en nychtémères égaux). Or, en ce moment, il trouva que le centre de la Lune était en 21° 21′ de la Vierge, et 1° 50′ au sud de l'écliptique Le temps sidéral étant au moment 106° (le milieu du Cancer était au méridien), la longitude apparente était de 172° 20′, et la latitude environ de 2°, nombres qu'il adapte aussi pour l'Épi.

Suivant nos calculs la date julienne sera 4420, 68 jours, et parceque, selon Ptolémée, les 4 heures temporaires valent 4 heures équinoxiales, la date complète de l'observation sera :

Année de l'ère chrétienne — 293, Mars 9, 8^h 0 temps vrai d'Alexandrie, ou 6^h à Greenwich.

On a trouvé pour le 9 Mars à midi l'équation du temps = + 13^m, et la déclinaison du Soleil = − 6° 21′. Le coucher du Soleil avait donc lieu, sous la latitude d'Alexandrie, à 5^h 45^m de temps vrai, d'où il s'ensuit que 2 heures temporaires valent 2^h 5^m temps vrai, c'est à dire : l'observation avait eu lieu à 7^h 50^m temps vrai d'Alexandrie ou à 8^h 3^m temps moyen = 6^h 3^m à Greenwich = Mars 9·252.

Les Tables de la Lune nous ont donné pour le méridien de Greenwich—

— 293 Mars	*l*	*b*	Π	*r*
9·j200	169° 58′ 36″·2	— 1° 49′ 14″·9	54′ 40″·8	14′ 55″·5
·225	170 16 46·8	47 59·9	40·3	55·3
·250	34 57·1	46 37·3	39·8	55·2
·275	53 7·0	45 7·0	39·4	55·1
·300	171 11 16·6	43 29·1	38·9	55·0
·325	29 25·9	41 43·6	38·4	54·9
·350	47 34·9	39 50·5	37·9	54·7

Il s'ensuit en employant $\epsilon = 23° 43' 58''·8$—

— 293 Mars	α	δ	θ	$\alpha' - \alpha$	$\delta' - \delta$	$r' - r$
9j200	170° 5′ 7″·3	+ 2° 20′ 44″·4	84° 8′ 52″	+ 46′ 46″·3	— 28′ 3″·6	+ 1″·1
·225	22 18·4	14 40·7	93 10 21	45 48·4	27 50·6	2·9
·250	39 32·0	8 43·7	102 11 50	43 46·2	27 39·3	4·6
·275	56 48·2	2 53·5	111 13 19	40 42·3	27 30·1	6·3
·300	171 14 7·0	+ 1 57 10·1	120 14 48	36 40·7	27 22·9	7·8
·325	31 28·4	51 33·5	129 16 17	31 46·9	27 17·8	9·2
·350	48 52·4	46 3·7	138 17 45	+ 26 7·6	— 27 14·8	+ 10·4

Pour — 300 + t on a pour α Virginis—

$$A = 171° 49' 58''·9 + 45''·49\,t, \qquad D = +1° 30' 39''·8 - 20''·07\,t,$$

ainsi au moment de l'observation—

$$A = 171° 55' 25''·8, \qquad D = +1° 28' 15''·6.$$

En calculant la distance s entre l'étoile et la Lune par les formules connues—

$$s \sin \psi = (\alpha' - A) \sqrt{\cos \delta' \cos D}$$
$$s \cos \psi = \delta' - D,$$

on a formé le tableau suivant—

— 293 Mars	$\alpha' - A$	$\delta' - D$	s
9j200	— 63′ 32″·2	+ 24′ 25″·2	68′ 2″·5
·225	47 19·0	18 34·2	50 48·9
·250	32 7·6	12 48·8	34 34·6
·275	17 55·3	7 7·8	19 16·9
·300	— 4 38·1	+ 1 31·6	4 52·7
·325	+ 7 49·5	— 3 59·9	8 47·1
·350	+ 19 34·2	— 9 26·7	21 43·5

Ensuite on a obtenu, par interpolation l'immersion et l'émersion de α Virginis, les résultats suivants—

Immersion Mars 9·286 = 6^h 46^m temps moyen de Greenwich.
Emersion Mars 9·337 = 8^h 6 „ „ „

Ce qui Timocharis énonce diffère ainsi environ de ¾ heures de notre calcul.

De plus on a pour les mêmes époques respectivement—

θ	Angle horaire	Azimuth	Hauteur
113° 44′ 55″	— 58° 5′	— 73° 28′	27° 44′
133 36 11	— 38 14	— 58 7	43 13

Finalement on trouve pour époque de la conjonction en ascension droite—

7^h 25^m temps moyen de Greenwich,

et, par suite, la différence—

$$\delta' - D = +12''·8$$

d'où il résulte—

la plus courte distance = 5″·2.
Au même époque on a ⊙ — ☾ = 172°·5.

D'après notre calcul, l'étoile n'a en aucune manière partagé en trois le diamètre de la Lune, comme Timocharis l'a observé.

3. *Conjonction des Pleïades observée par Timocharis.*

−282 *Janvier* 29.

Éd. Halma II. page 21.

Τιμόχαρις μὲν ἀναγράφει τηρήσας ἐν Ἀλεξανδρείᾳ ταῦτα, διότι τῷ μζ ἔτει τῆς πρώτης κατὰ Κάλιππον ἑξ καὶ ἑβδομηκονταετηρίδος τῇ η τοῦ Ανθεστηριῶνος, κατ' Αἰγυπτίους τῇ κθ τοῦ Αθύρ, ὥρας γ ληγούσης, τὸ νότιον μέρος ἥμισυ τῆς σελήνης ἐπιβεβηκὸς ἐφαίνετο ἐπὶ τὸ ἑπόμενον ἤτοι γ″ ἢ ϛ″ μέρος τῆς πλειάδος ἀκριβῶς.

Timocharis rapporte qu'en observant à l'Alexandrie, dans la 47^e année de la première période de Calippe, le 8 du mois Anthestérion, ou le 29 du mois égyptien Athyr, à la fin de la troisième heure, la moitié australe de la Lune lui parut s'en aller sur la partie suivante, c'est à dire sur le tiers ou la moitié des Pleïades.

Ptolémée dit que cette date répond à l'an 465 de Nabonassar, à 3 heures temporaires avant minuit du 29 au 30 Athyr, mais à $3\frac{1}{3}$ heures équinoxiales, parceque le Soleil était alors au 7° du Verseau (307°). En nychtémères égaux on trouve le même nombre d'heures avant minuit. En ce moment le lieu vrai de la Lune était en 0° 20′ du Taureau, avec la latitude boréale de 3° 45′. Les $\frac{2}{3}$ des Gémeaux passant le méridien (temps sidéral = 79°), la longitude apparente était de 29° 20′, et la latitude de 3° 55′. Pour l'extrémité suivante des Pleïades il fixa la longitude à 29° 30′ ; car le centre de la Lune la précédait. La latitude était de 3° 40′ environ, car la partie en question des Pleïades était un peu plus boréale que le centre de la Lune.

La date de l'observation sera par notre réduction, et d'après les donnés de Ptolémée—

— 282, Janvier 29, 8^h 40^m temps vrai d'Alexandrie.

Pour le 29 Janvier à midi on trouve l'équation du temps = + 17^m. La déclinaison du Soleil étant à même époque = − 19° 4′, le coucher du Soleil, sous la latitude d'Alexandrie, avait lieu à 5^h 12^m temps vrai. Comme ainsi les trois heures temporaires valent 3^h 24^m temps vrai, l'observation avait eu lieu à 8^h 36^m temps vrai d'Alexandrie, ou à 8^h 53^m temps moyen = 6^h 53^m temps moyen de Greenwich.

Les Tables de la Lune donnent pour le méridien de Greenwich—

— 282 Jan.	*l*	*b*	Π	*r*
29·j150	27° 43′ 17″·7	+ 3° 53′ 38″·4	57′ 7″·0	15′ 35″·4
.175	28 3 0·4	54 49·7	8·2	35·7
·200	22 44·0	56 0·6	9·4	36·0
·225	42 28·5	57 11·1	10·5	36·4
·250	29 2 13·9	58 21·2	11·8	36·7
·275	22 0·2	59 30·8	12·9	37·0
·300	41 47·3	+ 4 0 40·0	14·1	37·3
·325	30 1 35·3	1 48·8	15·3	37·7
·350	21 24·1	2 57·2	16·5	38·0

et en prenant $\epsilon = 23° 44' 10''\cdot 9$—

— 282 Jan.	α	δ	θ	α′ — α	δ′ — δ	r′ — r
29·j150	24° 13′ 54″·7	+ 14° 25′ 1″·8	27° 59′ 18″	— 3′ 21″·3	— 16′ 37″·0	+ 15″·2
·175	32 21·2	33 21·8	37 0 47	11 4·3	16 45·2	14·9
·200	50 49·8	41 40·7	46 2 16	18 32·1	17 10·8	14·3
·225	25 9 20·6	49 58·4	55 3 45	25 33·9	17 53·3	13·4
·250	27 53·6	58 15·0	64 5 13	31 59·8	18 51·9	12·3
·275	46 28·8	+ 15 6 30·4	73 6 42	37 40·7	20 5·4	10·9
·300	26 5 6·1	14 44·6	82 8 11	42 28·2	21 32·0	9·3
·325	23 45·7	22 57·7	91 9 40	46 16·1	23 9·9	7·6
·350	42 27·4	31 9·6	100 11 8	— 48 59·1	— 24 56·7	+ 5·7

Les tables citées ont donné pour η Tauri à l'époque — 280 + *t*—

$A = 24° 50' 50''\cdot 0 + 47''\cdot 63\, t,$ $D = + 14° 32' 56''\cdot 8 + 18''\cdot 40\, t,$

d'où il résulte pour — 282 Janvier 29—

$A = 24° 49' 18''\cdot 5,$ $D = + 14° 32' 21''\cdot 5.$

En ayant pris les différences α′ — A et δ′ — D, nous avons calculé la distance *s* entre l'étoile et le centre de la Lune. De cette manière on a—

— 282 Jan.	α′ — A	δ′ — D	s	☉ — ☾
29·j150	— 38′ 45″·1	— 23′ 56″·7	44′ 31″·2	277°
·175	28 1·6	15 44·9	31 23·5	
·200	17 0·8	7 51·6	18 14·4	
·225	— 5 31·8	— 0 16·4	5 21·2	
·250	+ 6 35·3	+ 7 1·6	9 29·3	
·275	19 29·6	14 3·5	23 31·4	
·300	33 19·4	20 51·1	38 21·2	
·325	48 11·1	27 26·8	54 4·7	
·350	+ 64 9·8	+ 33 51·4	70 39·2	

Par interpolation on a obtenu les résultats suivants—

Immersion de η Tauri Janvier 29·2047 = 4^h 55^m temps moyen de Greenwich.

Conjonction en asc. dr. „ 29·2366 = 5^h 41^m „ „ „ „ . et $\delta' - D = + 3' 9''\cdot 0$

Émersion „ 29·2613 = 6^h 16^m „ „ „ „

Le temps que Timocharis assigne diffère ainsi très considérablement de notre calcul.

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4. *Conjonction de α Virginis observée par Timocharis.*

— 282 *Novembre* 8.

Éd. Halma II. page 24.

Καὶ ἐν τῷ μη δὲ ἔτει τῆς αὐτῆς περιόδου, φησὶν ὁμοίως ὅτι, τοῦ μὲν Πυανεψιῶνος τῇ ς φθίνοντος, τοῦ δὲ Θὼθ τῇ ζ τῆς ι ὥρας ὅσον ἡμιωρίον προελθόντος, ἐκ τοῦ ὁρίζοντος ἀνατεταλκυίας τῆς σελήνης, ὁ στάχυς ἐφαίνετο ἁπτόμενος αὐτοῦ τοῦ βορείου ἀκριβῶς.

Il (Timocharis) dit encore que dans la 48ᵉ année de la même (première) période (de Calippe), à la fin du 6 du mois Pyanepsion, ou le 7 de Thot, au milieu de la dixième heure, la Lune ayant paru sur l'horizon, l'Épi y paraissait exactement toucher le bord boréal.

Selon Ptolémée la date de cette observation correspond à la 466ᵉ année de Nabonassar, à 3½ heures temporaires après minuit du 7 au 8 du mois égyptien Thot, ou à peu près à 3¼ heures Équinoxiales, le Soleil étant alors au milieu du Scorpion (225°). La Lune se leva à 2½ heures après minuit, car à ce moment, les 22½° des Gémeaux passent au méridien, et 22½° de la Vierge était à peu près à l'horizon. En réduisant en nychtémères égaux, Ptolémée trouve 2 heures après minuit,* ce qui est exact. A cet instant il trouve la longitude vraie de la Lune de 171° 30′, et la latitude de 2° 10′ au sud, et la longitude apparente de 172° 30′, et 2° 15′ au sud, ce qui est la position qu'il attribue pour l'Épi—

La date sera — 282, Novembre 8, 15^h 40^m temps vrai d'Alexandrie.

Pour le 8 Novembre à midi l'équation du temps = — 13^m. La déclinaison du Soleil étant à même époque = — 15° 40′, le coucher du Soleil avait lieu, sous la latitude d'Alexandrie, à 5^h 21^m de temps vrai. L'observation avait donc lieu à 15^h 25^m temps vrai d'Alexandrie, ou 13^h 39^m temps moyen de Greenwich.

D'après les Tables de la Lune on a—

— 282 Nov.	l	b	Π	r
8·j400	169° 8′ 45″·9	— 1° 54′ 18″·1	59′ 15″·1	16′ 10″·3
·425	29 59·7	56 2·0	15·0	10·3
·450	51 13·6	57 45·7	14·8	10·3
·475	170 12 27·5	59 29·0	14·6	10·2
.500	33 41·4	— 2 1 12·1	14·4	10·2
·525	54 55·3	2 54·9	14·2	10·1
·550	171 16 9·2	4 37·4	14·0	10·1
·575	37 23·0	6 19·6	13·8	10·0
·600	58 36·8	8 1·5	13·7	10·0

Par ϵ = 23° 44′ 9″·7—

— 282 Nov.	a	δ	θ	$a' - a$	$\delta' - \delta$	$l' - l$	$b' - b$	$r' - r$
8·j400	169° 17′ 20″·5	+ 2° 35′ 51″·1	37° 10′ 26″	+ 37′ 17″·2	— 31′ 44″·4	+ 46′ 49″·0	— 14′ 34″·7	— 9″·2
.425	36 9·3	25 52·0	46 11 55	42 1·9	31 26·8	51 3·9	12 20·2	7·4
·450	54 57·9	15 52·6	55 13 24	45 49·6	31 10·0	54 26·5	10 29·9	5·5
·475	170 13 46·3	5 52·9	64 14 53	48 35·0	30 54·5	56 52·6	9 6·3	3·6
·500	32 34·5	+ 1 55 53·0	73 16 21	50 14·1	30 40·9	58 18·5	8 11·3	— 1·7
·525	51 22·5	45 52·7	82 17 50	50 43·9	30 29·7	58 41·7	7 47·0	+ 0·4
·550	171 10 10·3	35 52·2	91 19 19	50 3·4	30 21·1	58 1·5	7 53·8	2·4
·575	28 57·9	25 51·3	100 20 48	48 13·1	30 15·2	56 18·2	8 31·4	4·5
·600	47 45·3	15 50·2	109 22 16	+ 45 18·3	— 30 12·4	+ 53 37·1	— 9 38·3	+ 6·7

Pour α Virginis à l'époque on a—

A = 172° 7′ 17″·5, D = + 1° 24′ 21″·4

et—

L = 172° 10′ 23″·1, B = + 1° 53′ 37″·4

Par conséquent, l'étoile se leva à 80° 34′ temps sidéral = 14^h 29^m temps moyen d'Alexandrie.

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* Voilà le sens que moi je donne à cet obscur passage. La traduction d'Halma est pourtant inintelligible

Par interpolation de la table suivante—

— 282 Nov.	$\alpha' - A$	$\delta - D$	$\odot - ☾$
8·j400	— 129′ 39″·8	+ 39′ 45″·3	
·425	106 6·3	30 3·8	
·450	83 30·0	20 21·2	
·475	61 56·2	10 37·0	
·500	41 28·9	+ 0 50·7	52°
·525	22 11·1	— 8 58·4	
·550	— 4 3·8	18 50·3	
·575	+ 12 53·5	28 45·3	
·600	+ 28 46·1	— 38 43·6	

on a obtenu pour $13^h\ 1^m$ la plus courte distance 18′ 26″·0, correspondante à $r' = 16'\ 12''{\cdot}1$.

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5. *Conjonction des Pleïades observée par Agrippa.*
92 *Novembre* 29.

Éd. Halma II. page 22.

Αγρίππας δὲ, ἐν Βιθυνίᾳ τηρήσας, ἀναγράφει ὅτι τῷ ῑβ ἔτει Δομετιανοῦ, κατ' αὐτοὺς Μητρώου ζ, νυκτὸς ὥρας γ ἀρχούσης, ἡ σελήνη ἐπεκάλυψε τῷ νοτίῳ κέρατι τὸ ἑπόμενον καὶ νότιον μέρος τῆς Πλειάδος.

Agrippa qui observait en Bithynie,* écrit que dans la 12ᵉ année de Domitien, lo 7 du mois Métroüs, au commencement de la troisième heure de la nuit, la Lune cacha par sa corne australe, la partie australe et suivante des Pleïades.

Ptolémée ajoute que cette date répond à la 840ᵉ année de Nabonassar, du 2 au 3 du mois égyptien Tybi, 4 heures temporaires ou 5 heures équinoxiales avant minuit, parceque le Soleil était au 5° du Sagittaire (245°). Réduite au méridien d'Alexandrie, l'observation s'est faite à 5⅓ heures équinoxiales avant minuit, ou, réduit en nychtémères égaux, à 5¾ heures. Le centre de la Lune était en 33° 7′ et sa latitude + 4° 50′. En Bithynie la longitude apparente était 33° 15′ et la latitude 4°. D'après cela Ptolémée fixa 33° 15′ pour la longitude et 3° 40′ pour la latitude de la partie suivante des Pleïades.

Suivant nos réductions et suivant ce que nous venons de dire, la date de cette observation sera l'an 92, Novembre 29, $6^h\ 40^m$ temps vrai d'Alexandrie.

A midi le 29 Novembre on a l'équation du temps = $- 8^m$, et la déclinaison du Soleil = − 21° 40′, d'où suit que le coucher du Soleil avait lieu sous la latitude de Nikomédie, à $4^h\ 40^m$ de temps vrai. 2 heures temporaires étant égales à $2^h\ 26^m$, l'observation avait lieu à $7^h\ 6^m$ temps vrai de Nikomédie, ou à $6^h\ 58^m$ temps moyen = $4^h\ 54^m$ temps moyen de Greenwich.

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* Malgré toutes nos recherches dans la géographie de Ptolémée et d'autres, nous n'avons pas réussi à trouver une ville nommée Bithynie. Or, Bithynie n'ayant pas existé, je présume que le lieu en question était Nikomédie, alors capitale de la province Bithynie. Pour Nikomédie nous avons adopté :—

Latitude + 40° 46′, Longitude $2^h\ 4^m$ de Greenwich.

Par les Tables de la Lune—

92 Nov.	l	b	Π	r
29·j100	31° 54′ 26″·3	+ 50° 1′ 14″·0	54′ 11″·8	14′ 44″·8
·125	32 12 21·4	0 53·0	11·5	44·8
·150	30 16·4	0 31·5	11·2	44·7
·175	48 11·2	0 9·5	10·8	44·6
·200	33 6 5·8	4 59 47·1	10·5	44·5
·225	24 0·2	59 24·1	10·2	44·4
·250	41 54·4	59 0·7	9·9	44·3
·275	59 48·4	58 36·7	9·5	44·2
·300	34 17 42·3	+ 4 58 12·3	9·2	44·1

Pour $\epsilon = 23^\circ\ 41'\ 12''\!\cdot 1$ on a—

92 Nov.	α	δ	θ	$\alpha' - \alpha$	$\delta' - \delta$	$r' - r$
29·j100	27° 51′ 38″·8	+16° 57′ 27″·0	314° 6′ 34″	+ 41′ 23″·9	— 30′ 34″·7	+ 5″·4
.125	28 9 13·2	17 3 28·8	323 8 3	39 10·4	28 50·8	7·0
·150	26 48·6	9 28·9	332 9 32	36 1·4	27 12·4	8·4
·175	44 25·0	15 27·5	341 11 1	32 1·1	25 41·8	9·6
·200	29 2 2·3	21 24·4	350 12 29	27 15·0	24 21·4	10·7
·225	19 40·7	27 19·7	359 13 56	21 49·7	23 13·3	11·5
·250	37 20·0	33 13·4	8 15 27	15 52·7	22 19·3	12·2
·275	55 0·3	39 5·5	17 16 56	9 32·5	21 40·8	12·7
·300	30 12 41·5	+17 44 56·0	26 18 24	+ 2 58·4	— 21 19·1	+ 13·0

Suivant mes tables citées on a pour η Tauri à l'époque $100 + t$—

$A = 29^\circ\ 55'\ 24''\!\cdot 8 + 48''\!\cdot 52\ t,$ $D = + 16^\circ\ 26'\ 39''\!\cdot 2 + 17''\!\cdot 53\ t$

d'où suit pour 92 Novembre 29—

$A = 29^\circ\ 49'\ 40''\!\cdot 9$ $D = + 16^\circ\ 24'\ 35''\!\cdot 0.$

Par inspection du tableau suivant, où $l' - L$ et $b' - B$ sont calculés par les formules citées dans 1, on trouve—

92 Nov.	$\alpha' - A$	$\delta' - D$	$l' - L$	$b' - B$	⊙ — ☾
29·j100	— 76′ 38″·2	+ 2′ 17″·3	— 68′ 27″·4	+ 27′ 54″·5	213°
·125	61 17·3	10 3·0	51 51·5	30 1·2	
·150	46 50·9	17 41·5	36 7·5	32 19·4	
·175	33 14·8	25 10·7	21 12·3	34 46·1	
·200	20 23·6	32 28·0	— 7 1·4	37 16·5	
·225	— 8 10·5	39 31·4	+ 6 29·5	39 46·4	
·250	+ 3 31·8	46 19·1	19 27·4	42 12·5	
·275	14 51·9	52 49·7	31 59·5	44 29·7	
·300	+ 25 59·0	+ 59 1·9	+ 44 12·5	+ 46 34·1	

que *l'occultation*, dont Agrippa a parlé, n'a pas eu lieu. Au contraire, à l'époque de conjonction en longitude, $5^h\ 6^m$, le calcul donne—

$$l - B = +\ 38'\ 30''\cdot 7,\ r' = 14'\ 55''\cdot 5,\ \text{l'angle horaire} = 35^\circ.$$

6. *Conjonction de α Virginis observée par Ménélaus.*
98 *Janvier* 10.

Éd. Halma II. page 25.

Μενέλαος δὲ ὁ γεωμέτρης ἐν Ρώμῃ φησὶ τετηρῆσθαι τῷ ᾱ ἔτει Τραϊανοῦ, Μεχὶρ ῑε̄ εἰς τὴν ῑς, ὥρας ῑ πεπληρωμένης, τὸν στάχυν ὑπὸ τῆς σελήνης ἠφανισμένον· μὴ ὁρᾶσθαι γὰρ, ἀλλ' ὥρας ῑᾱ ληγούσης τεθεωρῆσθαι προηγούμενον τοῦ κέντρου τῆς σελήνης, ἔλαττον τῆς διαμέτρου αὐτῆς, ἶσον ἀπέχοντα τῶν κεράτων.

Ménélaus dit avoir observé à Rome, dans la première année de Trajan, du 15 au 16 Méchir, à 10 heures passées, l'Épi caché par la Lune ; car, dit-il, on ne le voyait pas alors. Mais à la fin de la onzième heure, on l'aperçut précédant le centre de la Lune, moins que d'un diamètre, et elle était à égales distances des deux cornes.

Ptolémée dit : La date répond à la 845ᵉ année de Nabonassar, du 15 au 16 Méchir, 4 heures temporaires ou 5 heures équinoxiales après minuit, lorsque le centre de la Lune était à peu près sur l'Épi. Il était 6¾ heures équinoxiales au méridien d'Alexandrie, ou, en réduisant en nychtémères égaux, 6½ heures ou un peu plus. A ce moment la Lune était en longitude 175° 45′ et en latitude environ de 1° 20′ au sud. La longitude apparente était de 176° 15′, la latitude de 2° au sud, le quart de la Balance étant au méridien. La même position pour l'Épi.

D'après notre réduction, la date de cette observation sera 98, Janvier 10, $17^h\ 0^m$ temps vrai de Rome, ou $16^h\ 10^m$ à Greenwich.

A midi le 20 Janvier j'ai trouvé l'équation du temps = + 11^m. La déclinaison du Soleil étant à même époque − 22° 17′, le coucher du Soleil avait lieu, sous la latitude de Rome* à $4^h\ 34^m$ temps vrai, 4 heures temporaires valent donc $4^h\ 56^m$ temps vrai, c'est à dire : l'observation avait eu lieu à $16^h\ 56^m$ temps vrai de Rome, ou à $17^h\ 7^m$ temps moyen = $16^h\ 17^m$ à Greenwich (Janvier 10, 678).

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* Nous avons adopté pour Rome : Latitude + 41° 54′, Longitude $0^h\ 50^m$ de Greenwich. On voit au-dessus et dans l'observation suivante que Ptolémée a pris la différence Alexandrie — Rome = $1^h\ 20^m$, tandis qu'il l'indique dans sa Géographie comme étant $1^h\ 37^m\cdot 5$.

Selon les Tables de la Lune on a pour le méridien de Greenwich—

98 Jan.	l	b	Π	r
10·j630	176° 27′ 10″·6	− 1° 18′ 20″·0	57′ 39″·8	15′ 44″·3
·655	47 9·7	16 37·8	38·3	43·9
·680	177 7 8·8	14 55·5	36·8	43·5
·705	27 7·9	13 13·1	35·4	43·1
·730	47 6·9	11 30·5	33·9	42·7
·755	178 7 5·9	9 47·8	32·5	42·3
·780	27 4·9	− 1 8 5·0	31·1	42·0

et par $\epsilon = 23^\circ\ 40'\ 57''\cdot 2$—

98 Jan.	α	δ	θ	$\alpha' - \alpha$	$\delta' - \delta$	$r' - r$	$l' - l$	$b' - b$
10·j630	176° 13′ 38″·9	+ 0° 13′ 40″·6	167° 59′ 3″	+ 6′ 14″·4	− 38′ 36″·7	+ 11″·8	+ 21′ 12″·1	− 32′ 52″·3
·655	32 38·1	7 13·5	177 0 32	− 0 21·2	38 40·8	11·8	15 11·6	35 34·5
·680	51 37·3	+ 0 0 46·4	186 2 0	6 55·9	38 44·3	11·7	9 11·6	38 15·8
·705	177 10 36·5	− 0 5 40·7	195 3 29	13 20·3	38 46·9	11·6	+ 3 20·8	40 52·5
·730	29 35·6	12 7·8	204 4 58	19 25·3	38 48·2	11·5	− 2 13·0	43 20·1
·755	48 34·7	18 34·9	213 6 27	25 2·1	38 47·9	11·4	7 22·8	45 33·3
·780	178 7 33·8	− 0 25 2·0	222 7 56	− 30 2·2	38 45·7	+ 11·3	− 12 2·6	− 47 26·0

Pour α Virginis nos tables citées ont donné pour 100 + t—

$$A = 176^\circ\ 53'\ 13''\cdot 6 + 45''\cdot 51\, t, \qquad D = -0^\circ\ 43'\ 42''\cdot 0 - 20''\cdot 22\, t,$$

ainsi du moment de l'observation—

$$A = 176^\circ\ 51'\ 44''\cdot 0, \qquad D = -0^\circ\ 43'\ 2''\cdot 2$$

et—

$$L = 177^\circ\ 24'\ 50''\cdot 0, \qquad B = -1^\circ\ 55'\ 0''\cdot 7.$$

Par ces donnés on a dressé le tableau suivant—

98 Jan.	$l' - L$	$b' - B$	s	☉ − ☾
10·j630	− 36′ 27″·3	+ 3′ 48″·4	36′ 37″·9	
·655	22 28·7	2 48·4	22 38·5	
·680	− 8 29·6	1 49·4	8 40·9	
·705	+ 5 38·7	0 55·1	5 43·0	112°
·730	20 3·9	+ 0 10·1	20 3·0	
·755	34 53·1	− 0 20·4	34 52·0	
·780	+ 50 12·3	− 0 30·3	50 10·8	

Par interpolation on a déduit l'immersion et l'émersion de α Virginis, ainsi—

Immersion Janvier 10·667 = 16^h 0^m temps moyen de Greenwich.
Émersion „ 10·723 = 17 21 „ „ „ „

La fin de la onzième heure étant à 17^h 31^m, la différence entre les longitudes de la Lune et de l'étoile était—

$$l' - L = +\ 20'\ 3''\cdot 9 \text{ et } r' = 15'\ 54''\cdot 2.$$

7. *Conjonction de β Scorpii observée par Ménélaus.*
98 *Janvier* 13.

Éd. Halma II. page 27.

Μενέλαος δὲ, ὁμοίως ἐν Ρώμῃ τηρήσας, φησὶν ὅτι τῷ πρώτῳ ἔτει Τραϊανοῦ, Μεχὶρ ῑη ἐις τὴν ῑθ, ὥρας ῑᾱ ληγούσης, ἐφαίνετο ἐπ᾽ εὐθείας τῷ τε μέσῳ καὶ τῷ νοτίῳ τῶν ἐν τῷ μετώπῳ τοῦ σκορπίου ἡ νότιος κεραία τῆς σελήνης· τὸ δὲ κέντρον αὐτῆς ὑπελείπετο τῆς εὐθείας, καὶ τοσοῦτον ἀπεῖχεν ἀπὸ τοῦ μέσου, ὅσον ὁ μέσος ἀπὸ τοῦ νοτίου· ἐδόκει δὲ κατειληφέναι τὸν βόρειον τῶν ἐν τῷ μετώπῳ· οὐδαμοῦ γὰρ ἐφαίνετο.

Ménélaus, qui a également observé à Rome, dit que, la première année de Trajan, du 18 au 19 Méchir, à la fin de la onzième heure, la corne australe de la Lune, paraissait tomber en ligne droite avec l'étoile du milieu (δ Scorpii) et l'étoile australe (π Scorpii) du front du Scorpion ; que son centre était laissé à l'orient de cette ligne droite, et était autant éloigné de l'étoile du milieu, que celle-ci l'est de l'étoile australe. Il paraissait avoir couvert l'étoile boréale du front, car on ne la voyait pas.

Ptolémée ajoute que cette date tombe à l'année 845 de Nabonassar, du 18 au 19 Méchir, à 5 heures temporaires après minuit, ou à 6⅛ heures équinoxiales, le Soleil étant en 23° du Capricorne (293°). Il était donc 7½ heures de temps vrai et à peu près de temps moyen à Alexandrie. Le centre de la Lune était à 35° 20′ de l'équinoxe d'automne (longitude = 215° 20′), avec une latitude boréale de 2° 30′. La longitude apparente était de 215° 55′, et sa latitude boréale de 1° 20′, la fin des Serres étant au méridien. L'étoile la plus boréale du front du Scorpion devait avoir la même position.

D'aprés nos calculs la date de cette observation répond à 98, Janvier 13, 18^h 10^m temps vrai de Rome, ou 17^h 20^m à Greenwich.

Pour le 13 Janvier à midi l'équation du temps était de + 12^m, et la déclinaison du Soleil de − 21° 49′. Le coucher du Soleil, sous la latitude de Rome, avait donc lieu à 4^h 36^m de temps vrai. L'observation s'était ainsi faite à 18^h 10^m temps vrai de Rome, c'est à dire à 17^h 32^m temps moyen de Greenwich.

Nous avons tiré des Tables de la Lune—

98 Jan.	*l*	*b*	Π	*r*
13·j670	215° 7′ 36″·8	+ 2° 1′ 59″·6	55′ 11″·5	15′ 3″·9
·695	25 56·2	3 28·2	10·4	3·6
·720	44 15·1	4 56·6	9·2	3·2
·745	216 2 33·4	6 24·7	8·0	2·9
·770	20 51·2	7 52·6	6·8	2·6
·795	39 8·4	9 20·2	5·5	2·2
·820	216 57 25·1	+ 2 10 47·6	4·1	1·8

et par ϵ = 23° 40′ 57″·4—

98 Jan.	α	δ	θ	$\alpha' - \alpha$	$\delta' - \delta$	$l' - l$	$b' - b$	$r' - r$
13·j670	213° 29′ 33″·8	− 11° 26′ 53″·2	185° 22′ 50″	+ 19′ 59″·0	− 43′ 28″·9	+ 33′ 4″·7	− 34′ 15″·8	+ 7″·4
·695	47 40·5	31 37·1	194 24 19	14 1·1	25·6	27 29·1	36 15·0	8·0
·720	214 5 47·3	36 20·0	203 25 47	7 51·7	25·6	21 44·4	38 19·7	8·3
·745	23 54·1	41 1·5	212 27 16	+ 1 31·1	28·9	15 50·5	40 29·0	8·4
·770	42 0·9	45 41·8	221 28 44	− 5 0·9	35·6	9 47·4	42 44·3	8·3
·795	215 0 7·7	50 21·1	230 30 3	11 44·2	45·4	+ 3 35·2	45 4·8	8·1
·820	18 14·5	− 11 54 59·4	239 31 21	− 18 38·8	− 43 58·3	− 2 46·1	− 47 30·7	+ 7·6

De plus on a pour les étoiles—

β Scorpii { A = 214° 46′ 51″·5 D = − 12° 42′ 40″·5
 L = 216° 44′ 8″·6 B = + 1° 15′ 40″·6

δ Scorpii { A = 213° 9′ 30″·6 D = − 15° 20′ 50″.8
 L = 216° 7′ 47″·5 B = − 1° 44′ 59″·6

π Scorpii { A = 212° 17′ 33″·6 D = − 18° 45′ 23″·8
 L = 216° 30′ 22″·5 B = − 5° 15′ 32″·8

Ensuite nous avons formé à l'égard de β Scorpii le tableau suivant—

98 Jan.	$l' - \mathrm{L}$	$b' - \mathrm{B}$	s	☉ − ☾
13·j670	− 63′ 27″·1	+ 12′ 3″·2	64′ 34″·0	
·695	50 43·3	11 32·6	52 0·2	
·720	38 9·1	10 56·3	39 40·6	
·745	25 44·7	10 15·1	27 37·2	77°
·770	13 30·0	9 27·7	16 28·9	
·795	− 1 25·0	8 34·8	8 41·8	
·820	+ 10 30·4	+ 7 36·3	12 57·6	

On verra par interpolation que l'immersion de β Scorpii avait lieu à 18h 35m temps moyen de Greenwich.

OBSERVATIONS OF COMETS *c* and *e* 1881.

Made at Dun Echt Observatory with the Filar Micrometer of the 15·06-inch Refractor.

(Communicated by the Earl of Crawford and Balcarres.)

Comet 1881 *c* (Schaeberle).

Date—1881	Dun Echt Mean Time	Comet − *		α Comet	δ Comet	Observer
		$\Delta\alpha$	$\Delta\delta$			
a July 19, .	11h 48m 44s	− 7m 0s·63	+ 0′ 54″·3	5h 54m 22s·51	+ 40° 32′ 50″·2	J. G. L.
b „ 19, .	11 55 46	− 8 22·15	− 0 20·2	5 54 23·79	+ 40 32 54·3	„
c „ 19, .	12 20 23	− 7 52·70	− 2 20·7	5 54 25·74	+ 40 33 18·9	R. C.
a „ 19, .	12 37 25	− 6 56·45	+ 1 38·8	5 54 26·69	+ 40 33 34·7	„
b „ 19, .	12 37 25	− 8 19·20	− 0 18·9	5 54 26·74	+ 40 33 33·4	„
„ 20, .	11 47 34	− 0 2·22	− 5 48·4	5 56 19·46	+ 41 55 29·1	„
„ 26, .	12 17 36	− 5 17·33	− 8 6·7	6 10 55·14	+ 43 28 17·6	„

Adopted mean Places of Comparison-stars for 1881·0.

1881	*α*	Redn.	*δ*	Redn.	Authorities
a July 19,	6^{h} 1^{m} 20^{s}·93	+ 2^{s}·21	+ 40° 32′ 1″·2	− 5″·3	B.-W., V. 1971.
b „ 19,	6 2 43·73	+ 2·21	+ 40 33 19·8	− 5·3	„ 2020.
c „ 19,	6 2 16·23	+ 2·21	+ 40 35 44·9	− 5·3	„ 2009.
„ 20,	5 56 19·41	+ 2·27	+ 41 1 22·8	− 5·3	„ 1781.
„ 26,	6 16 10·08	+ 2·39	+ 43 36 31·1	− 6·8	„ VI. 383.

Remarks:

July 19. Diameter 6^{s} = 1′·1; very gradually and then very suddenly much brighter in the middle to a bright nucleus.

July 26. Clouds. Comet much condensed to a decided nucleus: power 122.

Comet 1881 *e* (Barnard).

Date—1881	Dun Echt Mean Time	Comet − *		*α* Comet	*δ* Comet	Observer
		Δ*α*	Δ*δ*			
Oct. 11, . .	7^{h} 24^{m} 27^{s}	+ 0^{m} 41^{s}·81	− 5′ 4″·8	13^{h} 46^{m} 5^{s}·56	+ 20° 26′ 9″·5	R. C.
„ 12, . .	7 2 37	− 2 25·28	− 10 59·9	13 46 24·98	+ 21 2 40·2	J. G. L.

Adopted mean Places of Comparison-stars for 1881·0.

1881	*α*	Redn.	*δ*	Redn.	Authorities
Oct. 11,	13^{h} 45^{m} 22^{s}·03	+ 1^{s}·72	+ 20° 31′ 24″·9	− 10″·6	D. M. + 20°, 2884, determined by a single measure only from 1 Bootis, the catalogue-places of which, as will be seen, are unusually discordant.
„ 12,	13 48 48·56	+ 1·70	+ 21 13 50·7	− 10·6	B. W. XIII 1035.

Mean Place of 1 Bootis for 1881·0.

	α	*δ*	Authorities
	13^{h} 34^{m} 59^{s}·55	+ 20° 33′ 28″·6	Lalande-Asten 25256.
	59·95	25·0	B. W. XIII. 691.
	59·535	29·42	Rümker (4410), 1 Bootis.
	59·35	32·4	Sonntag No. 30 (A. N. No. 797).
Mean,	13 34 59·60	+ 20 33 28·9	

Remarks:

Oct. 11. Comet about 2′ in diameter.

The observers' initials, R. C. and J. G. L., indicate respectively R. Copeland and J. G. Lohse.

A NEW VARIABLE STAR.

(Dun Echt Circular, No. 41, December 2.)

In a checked telegram of twelve words by the "Science Observer" code the following particulars have been received from Boston, U.S.

"Mr. Sawyer has discovered that the star D. M. + 1°, 3408 is a variable of the Algol type, with a period of 5·24 days, its brightness varying from $6^{m}{\cdot}0$ to $6^{m}{\cdot}7$; 1881 November 30·84 Greenwich M. T. being an epoch of minimum."

The star's place for 1882·0 is—

$$\text{A. R.} = 17^{h}\ 10^{m}\ 33^{s}; \qquad \text{Decl.} = +\,1^\circ\ 20'{\cdot}6.$$

Schjellerup in his Catalogue of Stars—Copenhagen 1864—already pointed out, that "This star seems to be variable as Lalande has 6^{m} but Bessel 7^{m};* Bremiker in the Academische Sternverzeichniss adds expressly, that he estimates it of the 8th mag.; Argelander has $5^{m}{\cdot}5$. It occurs in Lamont's Zone 101 with 7^{m} and in Zone 102 with 8^{m}."

Schjellerup has $7^{m}{\cdot}7$ in a clear sky on 1863 June 9. As pointed out by Mr. Hind, there is a note on the magnitude of this star in the Uran. Argent. p. 306, but the alleged nature of the variability was not detected at Cordoba.

COMET *g* 1881.

(Discovered by Swift on Nov. 16, at 11 p.m.)

Dun Echt Circular, No. 40 (Nov. 22). The "Science Observer" Boston, U. S. sends a code telegram of 24 words containing the subjoined particulars of a new comet:—

"Elements.

$$\begin{aligned} T &= 1882 \text{ February } 5{\cdot}35 \text{ Greenwich M. T.}\\ \left.\begin{aligned} \pi - \Omega &= 192^\circ\ 26'\\ \Omega &= 205\ \ \ 46\\ i &= 134\ \ \ 47 \end{aligned}\right\} &\ \text{Mean Equinox } 1881{\cdot}0\\ \log q &= 0{\cdot}14959 \end{aligned}$$

$$\Delta\lambda \cos\beta = +\,0'{\cdot}1; \qquad \Delta\beta = -\,2'{\cdot}9.$$

Ephemeris for Washington Midnight.

1881	α	δ	Brightness
Nov. 21,	$1^{h}\ 1^{m}\ 16^{s}$	$+\,68^\circ\ 58'$	1·18
25,	0 26 32	62 30	
29,	0 5 0	55 21	
Dec. 3,	23 51 8	+ 47 47	1·44

The elements, which present some resemblance to those of Comet I. 1792, were computed by Mr. S. C. Chandler from observations made by Mr. Wendell at Harvard College on Nov. 17, 19, and 20."

This is the earliest information of this comet received here.

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* 1822 July, 4.

Dun Echt Circular, No. 42 (Dec. 5). Mons. A. Palisa transmits from Vienna by a "Science Observer Code" telegram new elements and an ephemeris of Comet 1881 *g*, based on observations, taken on November 22, 25, and 27:—

Elements.

T = 1881, December 8·81 Greenwich M. T.

$$\left.\begin{aligned} \pi - \Omega &= 130^\circ\ 46' \\ \Omega &= 184\ \ \ 54 \\ i &= 143\ \ \ 33 \end{aligned}\right\}\ \text{Mean Equinox 1881·0.}$$

$\log q = 0{\cdot}28267$

Ephemeris for Berlin Midnight.

1881	α	δ	Brightness
Dec. 7,	$23^h\ 47^m\ 40^s$	$+\ 46^\circ\ 10'$	1·00
11,	23 42 0	41 1	
15,	23 38 24	36 22	
19,	23 36 24	$+$ 32 15	0·73

We have received the following observations of this Comet—

1881. Nov. 25, $14^h\ 55^m\ 19^s{\cdot}1$ M. T. Königsberg,

$\alpha = 0^h\ 29^m\ 33^s{\cdot}52$ $\qquad \delta = +\ 63^\circ\ 34'\ 41''{\cdot}8$

from 5 Ringmicrometer comparisons with A. Ö. 601, the mean place of which for 1881·0 is $0^h\ 33^m\ 47^s{\cdot}25 + 63^\circ\ 15'\ 43''{\cdot}3$.

J. FRANZ.

1881. Nov. 26, $10^h\ 34^m\ 43^s$ T. M. Roma

$\Delta\alpha = -\ 1^m\ 59^s{\cdot}82$ (10 confr.), $\Delta\delta = +\ 2'\ 30''8$ (10 confr.)

α app. $= 0^h\ 24^m\ 20^s{\cdot}84$ $\qquad \log p\,\Delta = 9{\cdot}7890$

δ app. $= +\ 62^\circ\ 19'\ 40''{\cdot}2$ $\qquad 0{\cdot}2767n$

Stella di confronto: κ Cassiopeiæ (529 Sterne); cometa debolissima.

P. TACCHINI.

RECENT LITERATURE.

"*G. Schiaparelli: Osservazioni astronomiche e fisiche sull'asse di rotazione e sulla topografia del pianeta Marte.*" (Atti della R. Acad. dei Lincei, Serie III, Transunti Vol. 5, 4 pp.)* In this paper Professor Schiaparelli has published a summary of various important deductions from his observations of Mars made in 1879–80 with the admirably defining instrument employed for the same purpose in 1877–78. The observations were commenced on Sept. 30, 1879 and were continued until the end of March 1880, but by far the greater number were obtained during the last three months of 1879, no fewer than 60 nights being available during that period. The position of the axis of the planet to the line of sight favoured the examination of the regions lying north of the Equator more than was the case in 1877. In December the position of the planet was in this respect nearly the same as in 1877, and, rather unexpectedly, it was found practicable to examine the southern regions

* We are indebted to Mr. C. E. Burton for the review of this paper.

as well as in that year. The same methods of observing, magnifying power &c. were used, but it was found that the use of a reddish yellow screen glass decidedly improved the definition. 89 measurements of the position of the southern polar spot were made in order to redetermine the direction of the axis of rotation, and by combining the results of this series with those obtained in 1877 the co-ordinates of the projection of Mars' north pole on the celestial sphere were found to be—

RA = 318° 7′·8 Decl. = + 53° 37′·1 Epoch 1880·01

whence are obtained for the same epoch the following data expressing the position of the equator of Mars with respect to three fundamental planes—

Plane	Ascending Node	Inclination
Earth's Equator	48° 7′·8	36° 22′·9
Ecliptic	84 28·3	26 20·6
Plane of Mars' orbit	86 47·7	24 52·0 [*]

assuming that for 1880·0 the obliquity of the ecliptic was 23° 27′·3 and the ascending node and inclination of Mars' orbit referred thereto respectively 48° 37′·9 and 1° 51′·0. By a reduction of Professor Hall's observations of the satellites to the same epoch and a collation of the result with those given above, it is shown that the planes of the orbits of the satellites coincide sensibly with that of the Martian Equator. The perihelion passage takes place in 333° 49′ helioc. long., and the southern solstice 36 days later in long. 356° 48′.

The constant correction to be applied to all the areographic latitudes of the former memoir amounts to 2°·97, subtractive for south, additive for north latitudes. The positions of fundamental points on the surface were either found by referring them by the micrometer to the centre of the southern snow spot or by observing their transits over the central meridian, at the same time measuring the distances of each spot from the extremities of that meridian. The 482 observations obtained in 1877 and 1879 fix the places of 114 points. The new chart of Mars is based on these positions, but the form and relative intensity of the markings have been derived from the observations of 1879 only. The new chart differs from the former one in showing not merely the outlines but the different degrees of intensity of the markings. Some changes in the aspect of the planet since 1877 were noted, partly attributed by the Author to his more prolonged study, but in some cases to real alterations. For example, in 1879 "Ausonia" is intersected by several dusky streaks not previously seen, one running south-eastward from the "Deltoton Sinus" to the "Mare Hadriaticum," another, very distinct, completely cutting off the "Chersonesus" from the remainder of "Ausonia." "Hellas" (Lockyer Land) is divided into nearly perfect quadrants by the "Alpheus" and a similar dusky streak at right angles thereto; the "Syrtis Magna" (Kaiser Sea) has increased in breadth at the expense of "Libya," and numerous "canals" have made their appearance in the previously well studied region to the north and east of "Solis Lacus" (Mr. Green's "Terby Sea"). Also the "Aranes" of 1879 is not that of

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[*] W. Herschel found 28° 42′, Bessel 27° 16′.

1877, though both objects are stated to have been seen sharply defined. Many such alterations in detail are evident on comparing the two charts, but all the principal features are perfectly alike. It is interesting to mark the unveiling of the southern portion of the Tycho Sea in 1879 and its connexion with De La Rue Ocean (Mare Erythræum) by no less than six of the enigmatical "canals" which were imperfectly seen in 1877 (owing to winter mist?).

"*Observations sur l'aspect physique de Jupiter pendant l'opposition de* 1878. *Par L Niesten.*" (Annales astron. de l'Obs. R. de Bruxelles, T. III, 35 pp. 4to and 4 plates.) The 47 drawings published in this paper were made with the 6-inch Merz refractor of the Brussels Observatory, and all the necessary details as to time, longitude of central meridian, magnifying power and state of the atmosphere are given in the text together with other notes on the aspect of Jupiter.

"*Astronomische Mittheilungen von Dr. Rudolf Wolf, No.* 53." (28 pp. 8vo.) In order to investigate personal errors in making settings on or between horizontal wires Dr. Wolf made first 120 observations of southern stars with his meridian circle, each observation consisting of two settings of a star midways between the horizontal wires, the settings being made at the first and last vertical wire in the field and one microscope being read after each setting. The difference between the two settings arising from the inclination of the horizontal wires was thus found = 6″·78 ± 0″·16. This value was now used to determine the personal equations between Professor Wolf and several other observers, by letting one of the latter make one of the two settings, while Prof. Wolf made the other and reduced his result to that of the other observer by adding or subtracting 6″·8. Very decided personal equations were thus found, one amounting to 2″·05 ± 0″·64, another to 1″·21 ± 0″·58.

The same number also contains a series of measures of sun spots made in 1879 and 1880 at the Zürich Observatory by Alfred Wolfer. Differences of RA and Decl. between each spot and both limbs of the sun were measured, the latter by the micrometer-screw, the former by observing transits over one wire with a chronograph. The image of the sun was projected on a screen. The heliographic co-ordinates were deduced by Spörer's method and are given with all details.

"*Reports of American Observatories*" occupy 42 pages of the report of the Smithsonian Institution for 1879. The reports are drawn up in accordance with the plan described above, p. 40; they were collected and arranged by Professor Holden and are very interesting, particularly on account of the details given as to the instrumental equipment of the various public and private observatories.

"*A Determination of the Solar Parallax from Observations of Mars made at the Island of Ascension in* 1877. *By David Gill, LL.D.*" (From the Mem. R. Astron. Soc., Vol. 46, 172 pp.). This memoir contains a very full and thorough discussion of the observations of the diurnal parallax of Mars made in 1877 with a Repsold Heliometer at Ascension. With his usual skill and energy Dr. Gill has produced a value of the Solar Parallax which must be ranked among the very best hitherto obtained. As this investigation will be easily accessible to most of our readers when the whole Vol. 46 of the "Memoirs" is published, we shall not enter into a lengthy description of it, the more so as this would require more space than we have at our disposal. The final result is $8''{\cdot}78 \pm 0''{\cdot}012$, a value which is very close to the limits which Mr. D. P. Todd has shown to be indicated by the investigations on the velocity of light (see above, p. 58).

REMARKABLE STAR SPECTRUM; NEW PLANETARY NEBULA.

On the evening of Nov. 24, I noticed that the spectrum of DM. + 36° 3987 has a bright band in the blue, so that the star seems to belong to the small class of objects like Rayet's stars in the same neighbourhood.

The next evening I found a very small planetary nebula (place for 1880, $20^h\ 6^m\ 26^s{\cdot}38$, $+37^\circ\ 3'\ 25''{\cdot}2$) south $3'\ 10''$ of B.-W. XX, 200 – 1 and following it $8^s{\cdot}38$. Except by its spectrum the nebula is undistinguishable from a star of the fourteenth magnitude. Two other faint stars follow it $2^s{\cdot}6$ and $2^s{\cdot}3$ respectively, north $37''$ and south $20''$ of the nebula.

Edward C. Pickering.

CORRECTIONS.

Page 9. For corrections, see p. 49.
„ 26, line 3 of foot note, *for* sous les latitudes, *read* sans les latitudes.
„ 41 to 47, *for* B.C. 708, 600, 548, *read* everywhere — 708, — 600, — 548.
„ 53, RA of No. 5630, *for* $12^h\ 11^m\ 23^s$ *read* $12^h\ 11^m\ 13^s$ (error in MS.)
„ 94, in 3rd observation of Astræa, *for* $18^s{\cdot}60$ *read* $18^s{\cdot}65$.
„ 95, in 2nd observation of Irene, *for* $16^s{\cdot}52$ *read* $6^s{\cdot}52$.
„ 205, line 17, *for* Vieweg *read* Fievez.

DATES OF PUBLICATION OF NOS. 1 TO 12.

No.	1,	containing pp.	1– 24,	published	January	24.
„	2	„	25– 40,	„	February	26.
„	3	„	41– 64,	„	March	26.
„	4–5	„	65– 98,	„	May	11.
„	6	„	99–122,	„	June	11.
„	7	„	123–142,	„	July	13.
„	8	„	143–166,	„	August	24.
„	9	„	167–186,	„	September	17.
,	10	„	187–206,	„	October	19.
„	11	„	207–222,	„	November	24.
„	12	„	223–242,	„	December	29.

Urania, Vol. I, Plate 1.

Fig. 1.

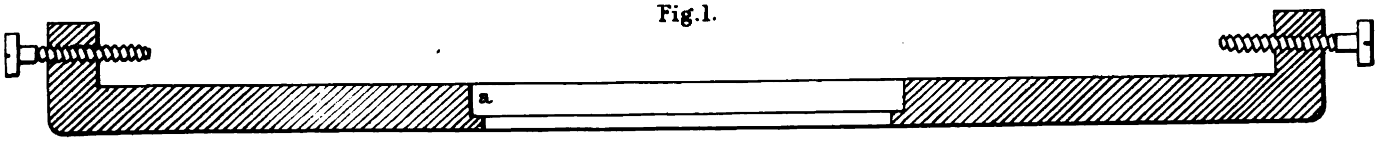


Fig. 2.

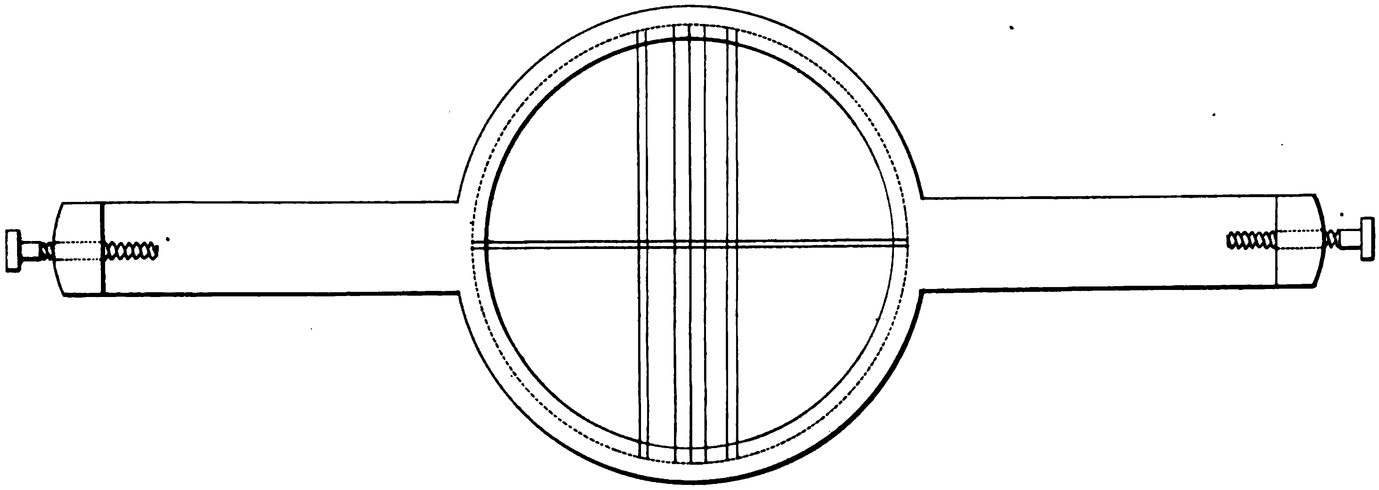
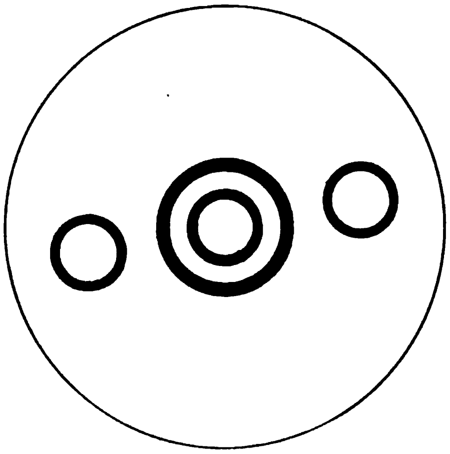


Fig. 3.



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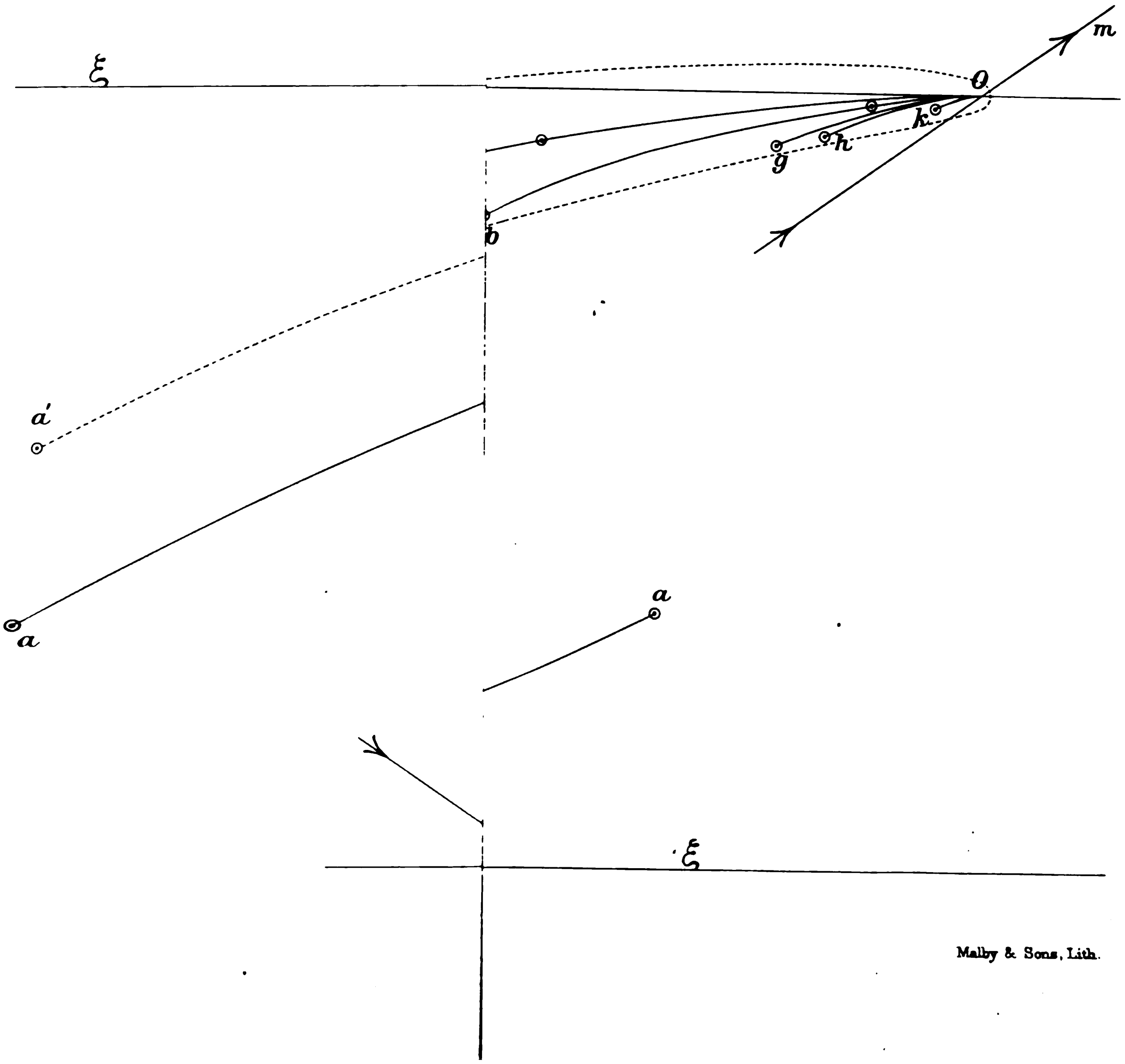
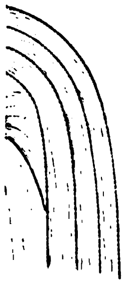
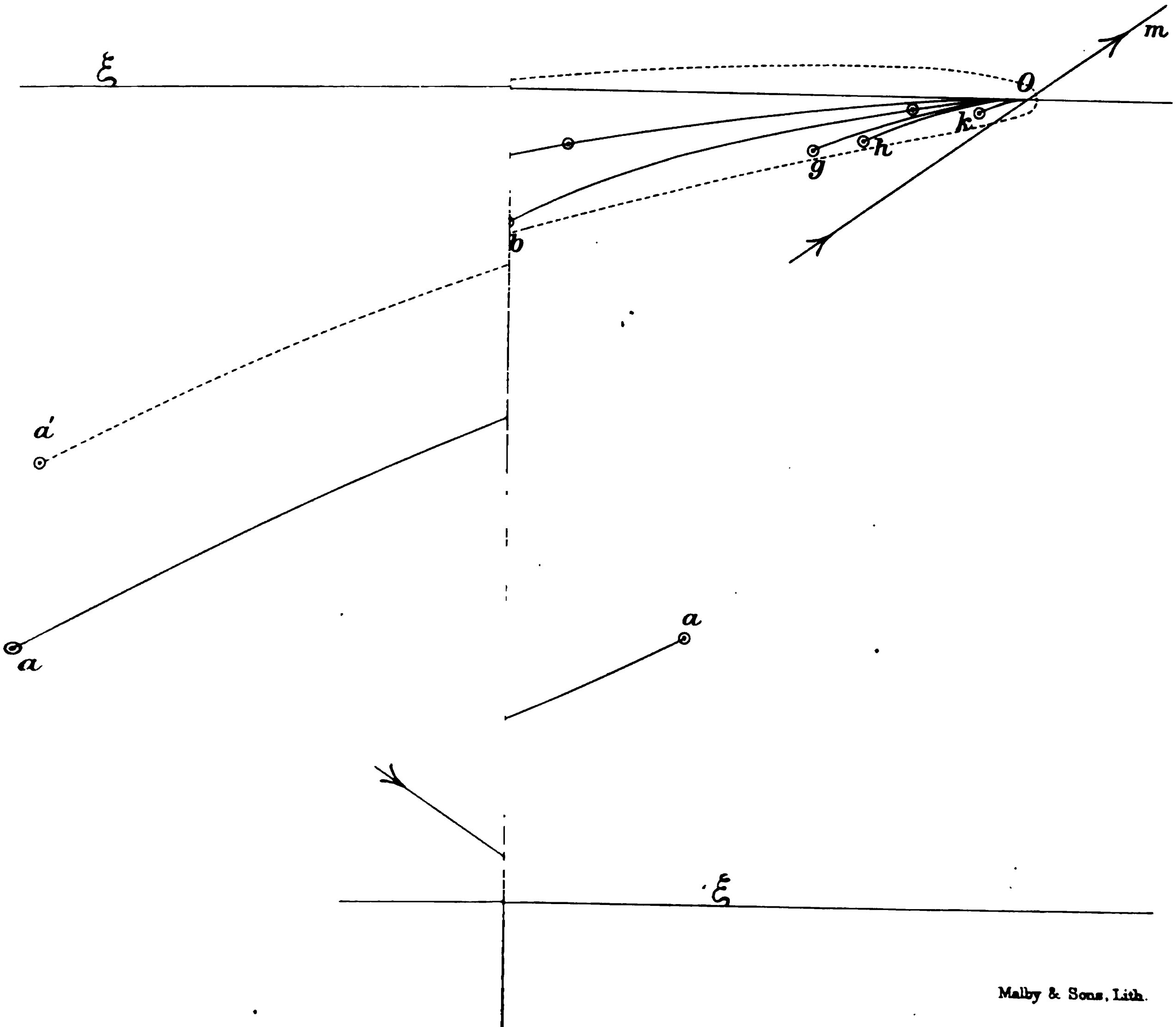


Malby & Sons, Lith.

Urania, Vol. I. Plate II.

2.





Malby & Sons, Lith.

Fig. 1.

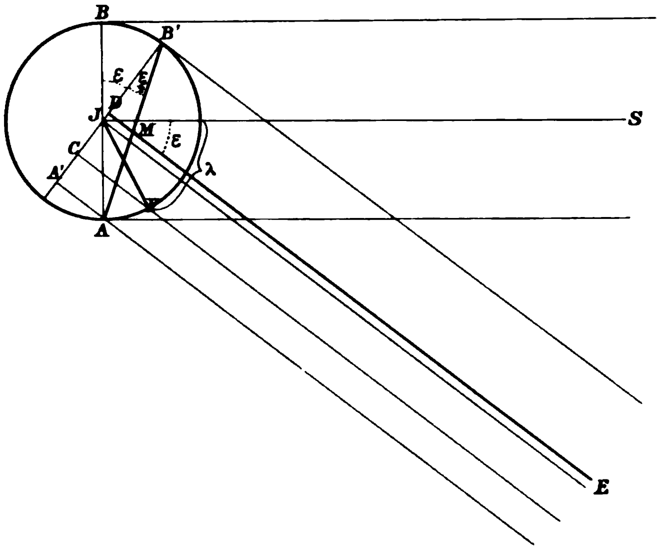


Fig. 2.

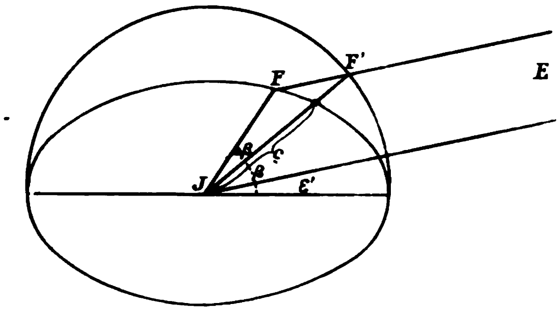
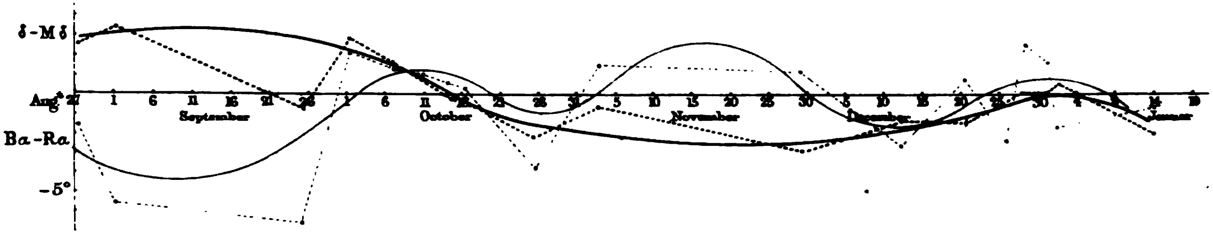


Fig. 3.



M.

27-inch Equatoreal for the Vienna Observatory.

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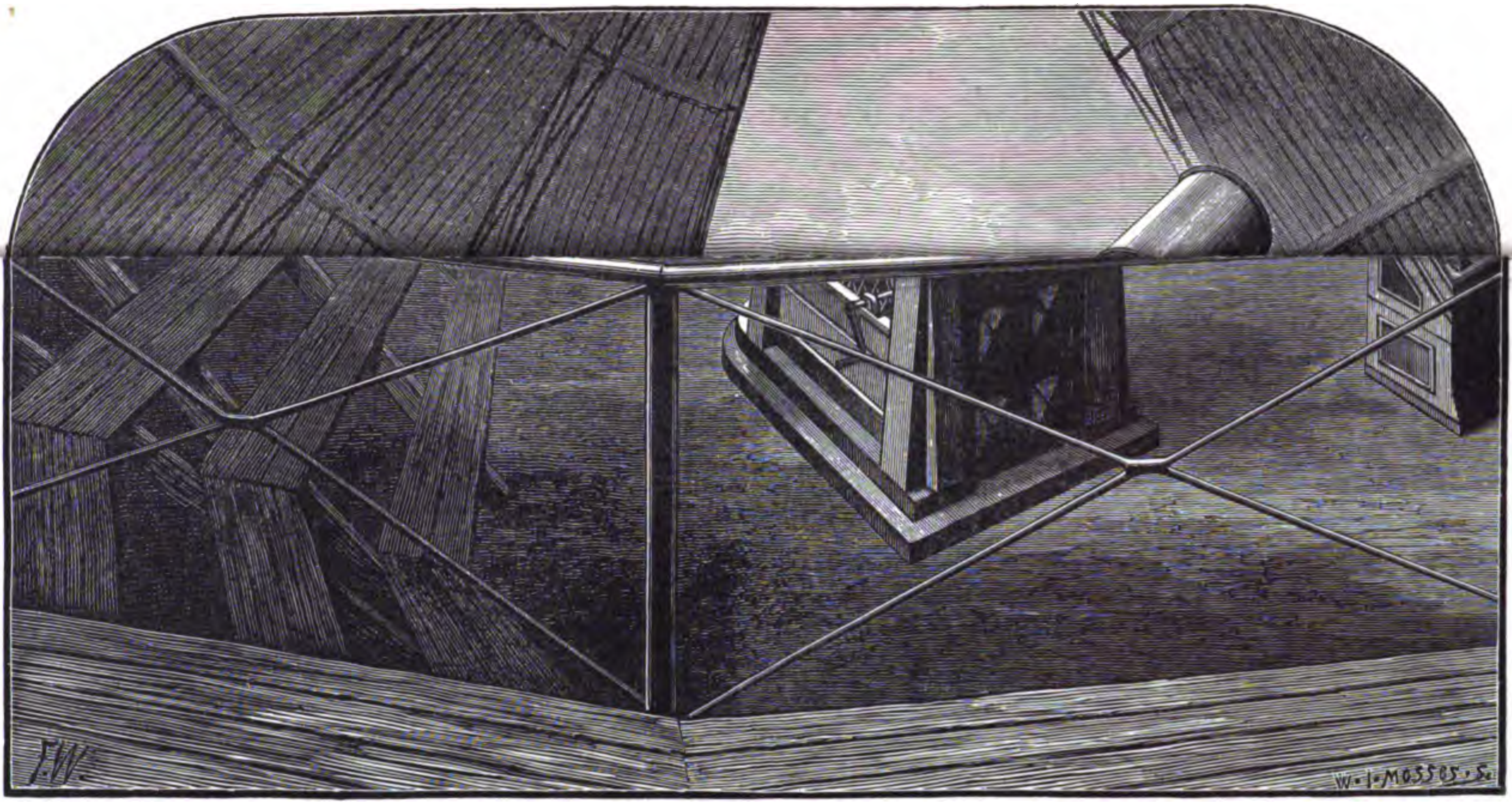

27-inch Equatoreal for the Vienna Observatory.

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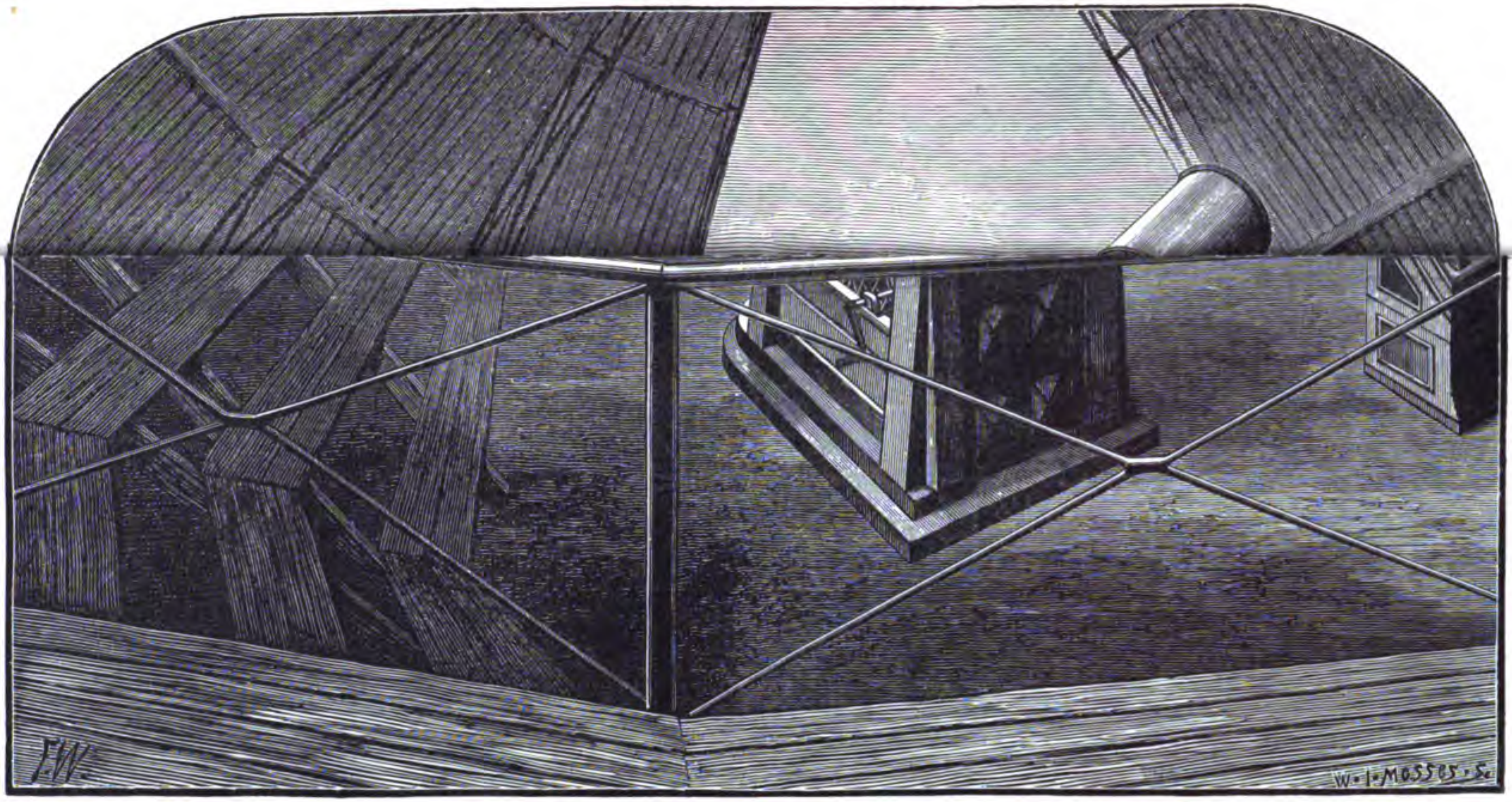

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